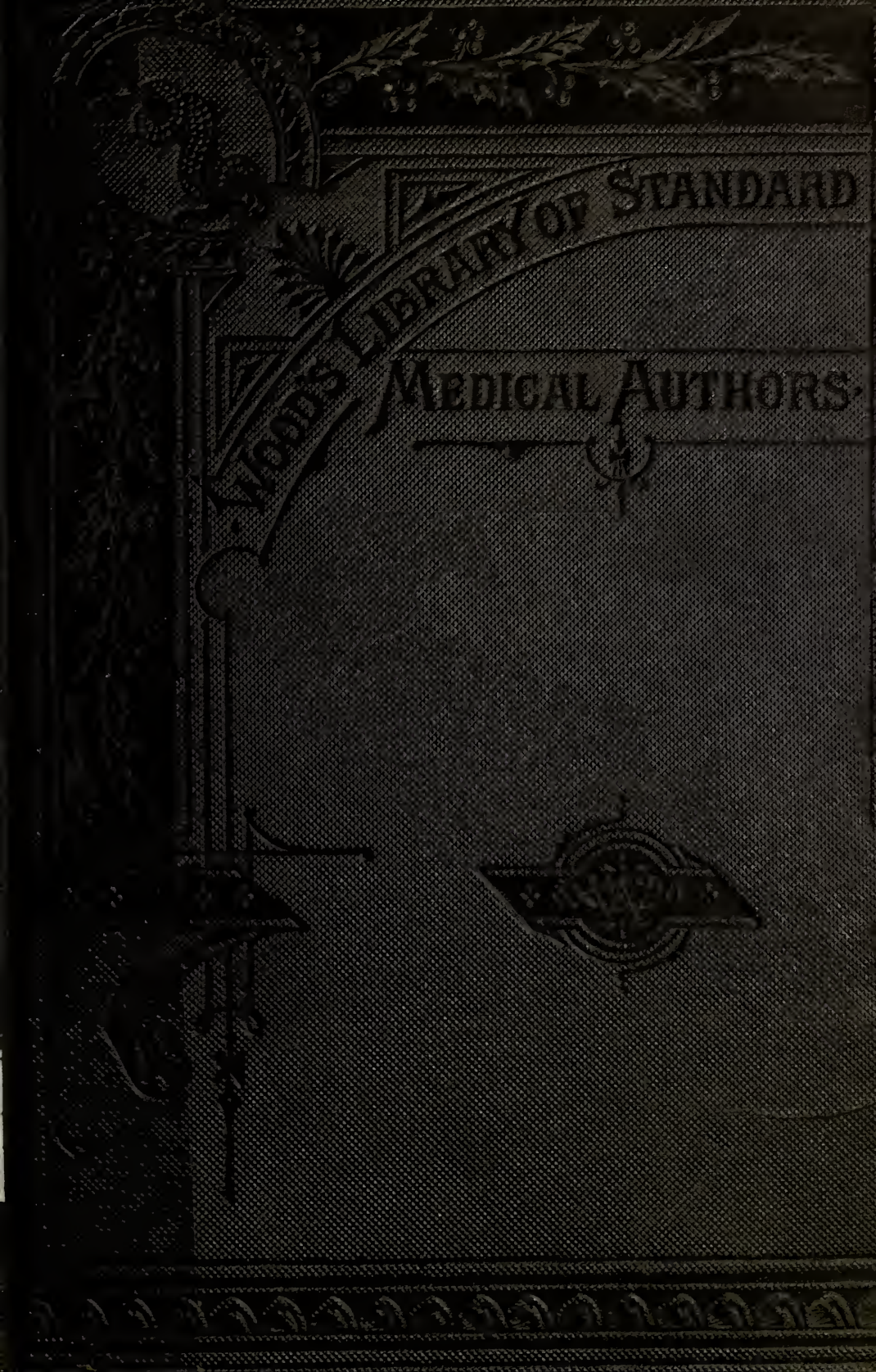
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MATERIA MEDICA

AND

THERAPEUTICS

INORGANIC SUBSTANCES

BY

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To

JOHN ERIC ERICHSEN, F.R.S.

EX-PRESIDENT OF THE ROYAL COLLEGE OF SURGEONS OF ENGLAND, SURGEON EXTRAORDINARY TO HER MAJESTY THE QUEEN

This Book is Dedicated

AS AN

EXPRESSION OF ESTEEM FOR HIS PROFESSIONAL ABILITY

AND OF

GRATITUDE FOR MUCH PERSONAL KINDNESS

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PUBLISHERS' PREFACE.

The first part of Dr. Phillips's "Materia Medica and Therapeutics"—the "Vegetable Kingdom"—edited by Dr. Piffard, was published in Wood's Library of Standard Medical Authors in 1879.

This, the concluding part, has but just been completed by the author, and is adapted to the United States Pharmacopœia, for this series, by Dr. Laurence Johnson. The author's text is presented entire; all additions are included in brackets.

O'Reilly, P.S.
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PREFACE.

This volume is published in succession to one upon the Vegetable Kingdom, and is arranged upon a similar plan. Several of our best modern treatises upon the same subjects completely separate pharmacology from therapeutics, but it has seemed to me better to recommend their simultaneous study, and I have devoted more space than is now usual to pharmaceutical chemistry; this will be to the advantage, I am sure, of the student, and I trust, of the practitioner. That ample space should be given to discussing the physiological action of medicines is a necessary condition of any modern work, and if the conclusions reached, and the bearings of facts gathered under this head, are still rather vague and undefined, they at least engage and deserve earnest attention, and point to the direction in which further advance may be made.

My former volume was published in 1874, and as some explanation of the long interval between it and the present one, I may say that in 1877 I had commenced arrangements with the printer when a serious railway accident interrupted my work, and incapacitated me for any exertion for upward of two years; the conditions under which I have now completed the book may perhaps be accepted as some apology for its defects.

During the interval, several excellent treatises on the same subjects have been published, and I have to acknowledge many obligations to those of Dr. H. C. Wood, Jr., Dr. Bartholow, Dr. Garrod, Dr. Ringer, as well as to the works of Trousseau, Stillé, Husemann, Nothnagel, Köhler, Gubler, and Rabuteau. I am also indebted to the "Poisons" of Dr. Taylor, the "Therapeutics" of Dr. Waring,

the "Commentary" of Dr. W. G. Smith, the "Handbook" of Dr. Fothergill, the "Companion" of Squire, and the "Chemistry" of Miller: the latter I have mainly followed as to mercury, iron, and other important drugs, but it is possible that some discrepancies may still be found between older and more modern chemical formulæ.

The "Medical Digest" of Dr. Neale I have found exceedingly useful. Various important monographs, *e.g.*, those of Preyer, Binz, Liebreich, Frazer, Brunton, and others, and valuable papers in various journals will be found quoted in their proper place.

The abbreviations and references will, I believe, be found sufficiently full for easy recognition. The *British and Foreign Medico-Chirurgical Review* is quoted either as *Brit. and For. Rev.* or as *Med.-Chir. Rev.*; the *Edinburgh Journal of Medicine* as *Edin. Journ.*; the *American Journal of the Medical Sciences* as *Amer. Journ.* or *Amer. Rev.*; *Practitioner* refers to the London journal of that name, unless otherwise specified; *Dub. Quart.* or *Dub. Journ.* to the *Dublin Journal of Medical Science.*

Finally, I have to thank Dr. Mackey, Dr. Menzies of Cannes, Dr. Port, and Mr. A. Pearce Gould, for their valuable assistance in looking up references and aiding me with many suggestions and corrections while the work was passing through the press.

2 Grosvenor Square, London, W.,
December 1, 1881.

CONTENTS OF VOL. I.

PAGE

OXYGEN—OZONE—COMPRESSED AIR 1–14

Physiological Action, External, 2; Internal, 2–8; Therapeutical Action, 8; Mode of Administration, 14.

NITROGEN 15

HYDROGEN 16

Peroxide of, 16.

CARBO—CHARCOAL 18–20

Therapeutical Action, External, 19; Internal, 19, 20; Preparations and Dose, 20.

SULPHUR 21

SULPHIDES OR SULPHURETS 22–34

Absorption and Elimination, 22; Physiological Action, External, 23; Internal, 23, 24; Therapeutical Action, External, 24; Internal, 28; Preparations and Doses, 33; Adulterations, 34.

PHOSPHORUS 35–57

Absorption and Elimination, 36; Physiological Action, External, 36; Internal, 37; Toxic Action, 40; Tolerance, 41; Theory of Action, 42; Antidotes, 44; Therapeutical Action, Internal, 45; Preparations and Dose, 57.

IODUM—IODINE 58–59

PAGE

COMPOUNDS OF IODINE—IODOFORM 59–94

Absorption and Elimination, 60; Physiological Action, External, 62; Internal, 62; Idiosyncrasy—Toleration. 68; Incompatibles, 69; Therapeutical Action, External, 70; Internal, 82; Preparations and Dose, 93.

BROMUM—BROMINE 94–97

Physiological Action, 95; Therapeutical Action, External, 96; Internal, 97.

COMPOUNDS OF BROMINE 97–120

Absorption and Elimination, 98; Physiological Action, Internal, 99; "Bromism," 100; Therapeutical Action, External, 104; Internal, 105; Preparations and Dose, 119.

CHLORUM—CHLORINE 120–124

Absorption and Elimination, 121; Physiological Action, External, 121; Internal, 122; Therapeutical Action, External, 123; Internal, 124; Preparations and Dose, 124.

AQUA—WATER 125–150

Absorption and Elimination, 125; Physiological Action, External (Forms of Bath), 125; Internal, 135; Therapeutical Action, External, 136; Internal, 149.

SEA-BATHING 150–153

Physiological Action, 151; Therapeutical Action, 152; Errors in, 152, 153.

MINERAL WATERS AND BATHS 153–180

Physiological and Therapeutical Action, 153, 154; Classification, 154.

ACIDUM ACETICUM—ACETIC ACID—GLACIAL ACETIC ACID 180

ACIDUM ACETICUM DILUTUM—VINEGAR 180–184

Absorption and Elimination, 181; Physiological Action, 181; Preparations and Dose, 183.

ACIDUM CARBONICUM—CARBONIC ACID 184–189

Absorption and Elimination, 184; Physiological Action, 185; Therapeutical Action, 187.

PAGE

ACIDUM CITRICUM—CITRIC ACID 189–191

Absorption and Elimination, 190; Physiological Action, 190; Therapeutical Action, 190; Preparations and Dose, 191.

ACIDUM HYDROCHLORICUM—HYDROCHLORIC ACID 191–199

Absorption and Elimination, 192; Physiological Action, 192; Toxic Action, 195; Therapeutical Action, External, 196; Internal, 196; Preparations and Dose, 199.

ACIDUM NITRO-HYDROCHLORICUM DILUTUM — DILUTE NITRO-HYDROCHLORIC ACID 199–201

Physiological and Therapeutical Action, 200; Preparations and Dose, 201; Bath, 201.

ACIDUM HYDROCYANICUM DILUTUM—DILUTED HYDROCYANIC ACID 202–215

Absorption and Elimination, 203; Physiological Action—Toxic Action, 204; Theory of Action, 209; Antidotes, 210; Therapeutical Action, External, 211; Internal, 212; Preparations and Dose, 214.

ACIDUM NITRICUM—NITRIC ACID 215–221

Absorption and Elimination, 216; Physiological Action, 216; Therapeutical Action, External, 217; Internal, 219; Preparations and Dose, 221.

ACIDUM PHOSPHORICUM DILUTUM—DILUTE PHOSPHORIC ACID 221–227

Absorption and Elimination, 222; Physiological Action, 222; Therapeutical Action, 224; Preparation and Dose, 227.

ACIDUM SULPHURICUM—SULPHURIC ACID 227–233

Absorption and Elimination, 227; Physiological Action, 228; Therapeutical Action, External, 230; Internal, 231; Preparations and Dose, 233.

ACIDUM SULPHUROSUM—SULPHUROUS ACID 233–247

ALKALINE SULPHITES AND HYPOSULPHITES 234–247

Absorption and Elimination, 235; Physiological Action, External (Disinfection), 235; Internal, 236; Therapeutical Action, External, 237; Internal, 243; Preparations and Dose, 247.

PAGE

ACIDUM TARTARICUM—TARTARIC ACID 247–249

Absorption and Elimination, 248; Physiological Action, 248; Therapeutical Action, 249; Preparation and Dose, 249.

AMMONIUM—AMMONIA GAS 249–250

COMPOUNDS OF AMMONIA 250–264

Absorption and Elimination, 252; Physiological Action, 253; Therapeutical Action, External, 257; Internal, 259; Preparations and Dose, 263.

ALUMINUM—ALUM 265–266

COMPOUNDS OF ALUMINA 266–275

Absorption and Elimination, 266; Physiological Action, 266; Theory of Action, 268; Therapeutical Action, External, 268; Internal, 271; Preparations and Dose, 275.

ANTIMONIUM—ANTIMONY AND COMPOUNDS 275–298

Absorption and Elimination, 278; Physiological Action, External, 279; Internal, 279; Theory of Action, 285; Tolerance, 286; Antidotes, 286; Therapeutical Action, External, 287; Internal, 287; Preparations and Dose, 297.

MATERIA MEDICA

AND

THERAPEUTICS.

INORGANIC SUBSTANCES.

OXYGEN, O,=16—OZONE, O_3.

Oxygen is the most universally diffused element, forming part of the air, the water, the earth, and of the tissues of plants and animals. Of the air it constitutes 23.01 per cent. by weight, 20.81 per cent. by measure, being about one-fifth part. By Priestley, who discovered it (in 1774), it was named "dephlogisticated or vital air."

Ozone is an allotropic form of oxygen. Its discoverer, Schönbein, did not arrive at a knowledge of its real nature, but Odling (in 1860), by a "splendid hypothesis," concluded it to be a *condensed* condition of oxygen, and this was afterward verified, among other observers, by Brodie, who adopted the symbol O_3, implying that *three* atoms of oxygen are condensed in each *one* of ozone. A minute proportion of it is found in the atmosphere—more in that of the open country and of the sea than in that of towns, but its precise distribution and variation are not yet ascertained. Richardson calculated its amount as 1 in 10,000 of air ("British Association Report," 1865).

Preparation.—Oxygen may be obtained pure from most of its combinations, but is conveniently and usually prepared by heating the peroxide of manganese, or the chlorate of potash, or both together. The former yields about one-ninth of its weight of oxygen. $3MnO_2=MnO, Mn_2O_3+2O$; or $2KClO_3=2KCl+3O_2$.

Ozone is produced in small quantities during the slow oxidation of phosphorus and some other substances. Lender recommends for its evo-

lution in sick chambers a mixture of peroxide of manganese, permanganate of potash, and oxalic acid, to be dissolved in water. In the laboratory it is prepared by passing a succession of electric sparks through a closed chamber filled with air.

Characters and Tests.—The principal characteristic of oxygen is its energetic power of combination with organic principles, and with minerals, to form acids and salts (oxidation), and with hydrogen to form water. It is a gas devoid of color, odor, or taste, of sp. gr. 1.1057 (atmospheric air being taken as 1). Under a pressure of 320 atmospheres, and at a temperature of —220° F., it has been liquefied by Pictet (1877).

Ozone is much denser than oxygen, and in most chemical and physical, though not in all vital effects, it is more active; it is further distinguished by a peculiar odor; also it is a powerful oxidizing agent, and changes many protosalts into persalts; it displaces iodine from some of its combinations, hence iodized starch paper is used as a test for the gas —the paper turns bluish as iodine is set free, and combines with the starch, but the test is not very dependable. Ozone is absorbed by turpentine.

According to Paul Bert, it possesses marked antiseptic properties, and animal substances keep long unputrefied in an atmosphere to which a minute proportion of ozone has been added (*Medical Record*, 1876; *Comptes Rendus*, t. 80).

Physiological Action (External).—The external and local action of oxygen in contact with mucous membrane or denuded skin is moderately stimulating.

Physiological Action (Internal).—To describe fully the physiological action of oxygen would involve a description of the processes of respiration, sanguification, nutrition, and tissue-change, for to all these, and to life itself, it is essential. If it be deficient in the respired air, or if it be insufficiently absorbed, all the functions become disordered, assimilation is impeded, circulation diminished, and temperature lowered, and if its access to the lungs be prevented for a few minutes, life altogether ceases. But we are concerned, at present, only with the results of certain experiments in which animals or men have been made to respire either pure oxygen, or an atmosphere artificially charged with a definite proportion of the gas, and the first question that arises is whether more than a normal amount of oxygen can be taken into the blood under such circumstances.

It was early proved that animals kept under a bell-jar filled with oxygen lived longer than in ordinary air; and also that animals made to breathe oxygen could resist asphyxia longer than similar animals that had breathed only air (Priestley, Beddoes), but Regnault and Reiset, while corroborating the former observation, concluded, from a series of experiments, that breathing an atmosphere rich in oxygen, or even one of

the pure gas, did *not* make the blood take up more oxygen than it would from ordinary air, nor was more carbonic acid excreted in consequence (*Annales de Chimie*, 1844). But these conclusions, which had much influence on professional opinion at the time, have been disproved. Preyer showed that a greater saturation from oxygen-inhalation is, *à priori*, probable, and that ordinary arterial blood is not fully saturated with oxygen —that it can take up more by being shaken with the gas. Demarquay proved it by showing that suppurating, indolent, or unhealthy wounds on the extremities of animals became quickly florid and hyperæmic when pure oxygen was inhaled; an extra amount of the stimulating gas must clearly have been carried by the circulation to the wound. Allen and Pepys, and later, Limousin, showed, by inhaling an equal quantity of atmospheric air at one time, and of oxygen at another, that, after the latter, double the amount of carbonic acid was expired, and this increase continued fifteen minutes after the inhalation had finished. Other observers have reported that the elimination of uric acid during a course of oxygen-inhalation is markedly lessened, *i.e.*, that more complete combustion occurs within the system (Schmidt's *Jahrb.*, 1865, t. 1, s. 28); thus, Kollmann found that while 300 grammes of the ordinary secretion of urine contained 236 milligrammes of acid, the same quantity contained only 122 milligrammes after inhalation of 12 litres of oxygen. On another occasion the amount of acid came down from 134 milligrammes to 25 milligrammes.

A clinical illustration, pointing in the same direction, is given by Gubler. After several copious draughts of the pure gas in an active nascent condition, the respiratory movements and the pulse became slower, a general sense of comfort was felt, and, without any dyspnœa, the pause between expiration and inspiration could be much prolonged. Thus, taking thirty seconds as a maximum time during which the breath may be "held" after breathing atmospheric air, it rises to ninety to one hundred seconds after breathing oxygen. From other observations, Gubler concludes that the blood receives the gas in proportion to its physical capacity for it, rather than in proportion merely to the vital necessity of hæmatosis: the globules absorb what they need, while any excess circulates free, and enters into combination only as the hæmoglobulin loses oxygen in passing through the capillaries. Hence, the amount of oxygen absorbed by an individual is proportionate to the number of his corpuscles (we should now say of his hæmoglobin), and a plethoric man quickly using up his reserve air breathes faster than a healthy one. On the other hand, an anæmic patient also breathes more rapidly than normal, since his corpuscles are either too few in number or otherwise altered, so that they cannot take up enough oxygen.[1] Buchheim states an opposite view, viz.,

[1] "Quinquaud, availing himself of the reducing properties of sodic hydrosulphite, was enabled to calculate the maximum quantity of oxygen capable of being absorbed

that oxygen is not absorbed proportionally to the amount of it brought to the lungs, but to its requirement for tissue-change; yet even he admits that the amount taken in can be increased to some extent by continued deep inspirations, and by breathing air rich in oxygen or under high pressure; he only denies that such adventitious oxygen affects the tissue-change (*Archiv für Exper. Pathologie:* Klebs, Bd. iv., 1875); he admits also that improvement in symptoms may result from breathing compressed air or pure oxygen, but thinks we cannot hope to influence the course of illness by increasing the amount of oxygen contained in the blood.

Granting, then, the possibility of taking into the blood more than the normal amount of the gas, it yet remains true that in many *healthy* persons no marked effect is to be noted from inhalations of fifteen to thirty litres of oxygen, unless it be a sense of warmth in the mouth and at the epigastrium (Husemann).

Naoumoff and Beliaieff, breathing it for seven to seventeen minutes, found no appreciable change in pulse or temperature, whilst in dogs made to breathe alternately air and oxygen, the temperature rose sometimes with the latter a few tenths of a degree, and there seemed some dilatation of capillaries (Abstract, *Lancet*, i., 1875).

Mr. Savory, partly following Regnault and Reiset, and partly relying upon observations with animals which showed no increase of temperature under oxygen-inhalations, has also argued that these can exert no effect on the system; but Dr. Edward Smith has pointed out that such experiments, to be conclusive, should extend over long periods, and take account of changes in diet, etc.; he himself found evidence of increased chemical change under oxygen.

In some persons, inhalation of the gas causes temporary nerve-symptoms, such as exhilaration, sense of vigor, heat of skin, tingling of fingers, and even pain referred to the fifth nerve (Husemann). I have myself observed all these symptoms, except the last, immediately after the inhalation; also some giddiness, and some rise of pulse, probably from extra effort in breathing; in the delicate, improved appetite, improved motor power, and sleep have followed. I can corroborate this observation, which has been made by Birch, Demarquay, and others. Oxygen, then, is not without effects, though these vary with different individuals, and we cannot yet reduce them to precise scientific expression.

Dr. Richardson, judging partly from a case in which the blood passed from the lungs back to the right heart, and so circulated "surcharged with oxygen," states that such excess leads to great exhaustion of mus-

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by a given amount of blood. The mean capacity in health, he found, was 240 cubic centimetres of oxygen to every 1,000 grammes of blood=128 grammes hæmoglobin." He assumes that this absorption capacity is invariable, but in reality it varies according to illness, especially in forms of anæmia. (Coupland: Gulstonian Lectures, March, 1881).

cular and nerve-power and constant perspiration (*Lancet*, ii., 1878), but the conditions are not simple enough for asserting that these symptoms are solely due to the gas. If an animal be kept in a closed vessel full of oxygen, it dies—we cannot exactly say why. Broughton discovered that rabbits, guinea-pigs, sparrows, etc., thus kept, were at first lively and excited with quickened circulation and respiration, but passed in an hour's time into a weakly, depressed condition, and finally died, although the air in the bell-jar was still pure enough to rekindle a flame. Dr. Richardson obtained similar results with oxygen that had been breathed and then purified, and he inferred that some principle essential to life was removed from the gas in the process of respiration (*British Medical Journal*, ii., 1860). He found in the animals after death a condition of "hyperinosis," and Demarquay, who met with analogous results, describes the volume of the blood as apparently much increased, the muscular and other tissues brightly red, the venous blood distinctly to be recognized, but less dark than usual, and more quickly reddened on exposure, the lungs congested being "intensely red," and all the viscera unduly vascular. The same observer states that a small amount of gas may be passed directly into the blood by careful intravenous injection, and in such cases, after death, the spleen is markedly redder than usual.

Theory of Action.—Rosenthal concluded from certain experiments that an increased amount of oxygen in the blood caused "apnœa," for if, after blowing in air for twenty to sixty minutes through the trachea of an animal, the artificial respiration be suddenly interrupted, the animal remains motionless and without breathing for twenty to forty seconds, then respiratory action, at first weak, ultimately normal, returns. Now, this being an opposite condition to one of *dyspnœa*, and the latter being dependent upon *want* of oxygen and consequent extra stimulus of the respiratory centre, he argued that apnœa must depend on overmuch oxygen. Ewald also, by experiment, determined some slight increase of oxygen in the blood in apnœa; Hering not so. In any case there is really no causal relation between the two facts (Buchheim: loc. cit.), nor is apnœa complained of after oxygen-inhalation or condensed air treatment.

Experiments of this nature, though very interesting, cannot be taken as practical guides in the clinical use of the gas, and, under ordinary conditions of inhalation, oxygen never causes the lung-inflammation and exaggerated vital processes predicted by Beddoes and others.

Direct Influence of Oxygen on the Heart.—Some observations by Cyon on this subject deserve notice. Separating the heart of a frog, he connected it with a system of glass tubes and a manometer, and then passed through its cavities, first, serum saturated with carbonic acid gas, and afterward serum saturated with oxygen. The former caused sudden arrest in diastole, while the latter restored the movements of the heart. Mr. Erichsen found, in experiments on asphyxiated animals, that ventri-

cular contraction could be re-excited by oxygen when ordinary air had no effect. According to Hermann, oxygen is not indispensable for the cardiac contractions—they may occur without it, but irregularly; and if the gas be absent, or supplied in insufficient quantity, regular and synchronous contractions are impossible (Robin's *Journal d'Anatomie et de Physiologie*, 1868–70).

Musculo-Nervous System.—Many observers have localized in the muscular system the special action of oxygen, and Spallanzani, finding that a chrysalis absorbed much less of the gas than a butterfly, argued that the difference was determined by the less movement of the former. Brown-Séquard has shown, by interesting experiments, that when the muscular and the nerve tissues have lost their vital properties, they may recover them under the influence of freshly oxygenated blood ("Journal," 1858). Thus, having injected some of his own blood (defibrinated and charged with oxygen) into the radial artery of a man executed thirteen hours previously, and whose limbs were quite rigid, muscular irritability returned to the hand. In another case he removed the arm, and three hours later, when rigor mortis was complete, he injected dog's blood through the brachial artery, and the rigidity disappeared, first in the fingers, then in other parts; the skin resumed its color, became elastic and supple, and the hair-bulbs projected (goose-flesh). In animals the vital qualities could not be restored so long after death; but, in one curious experiment, the head of a dog being cut off, was injected through the carotid and vertebral arteries, and movements of the eyes and the face-muscles continued for a quarter of an hour. Other observations have proved that oxygen augments the vital functions of the spinal cord and motor and sensory nerves, and that, by the continued injection of blood charged with it, a dead body resists decomposition for upwards of fifty hours. Richardson, injecting oxygen into the arteries of recently killed animals, tested the muscular irritability by Faradic currents, and found that the gas (warmed to 75° F.) increased irritability very much, but only for a short time. The onset of permanent rigidity was rather hastened.

Compressed Air.—Physiological Action.—This varies somewhat according as to whether the patient is wholly immersed in an atmosphere of air compressed to one-half to one atmosphere in a closed chamber for one or two hours, or whether he simply breathes it from a reservoir through a tube with closely fitting mouthpiece for twenty to sixty inspirations.

The former and older method, as carried out by Reichenhall, often caused oppression of head, tinnitus, and other disagreeable sensations, but had a sedative and equalizing effect on the circulation, slowing heart-action, raising arterial tension and altering the distribution of blood, lessening its amount in the veins and increasing it in the arteries. It increased also expectoration and excretion (Burdon Sanderson: *Practitioner*, vol. i.).

In the more recent method employed by Waldenburg and Biedert, the extra compression amounts to only $\frac{1}{100}$ to $\frac{1}{45}$ atmosphere, and the good results obtained are more clearly traceable to the extra amount of oxygen. Nutrition and blood-formation are improved, the "lesser circulation" is rendered freer and less congested, and at the same time the vital capacity of the lungs is increased. The alternate use of *rarefied* air, which induces rather opposite conditions, is employed in this method (*Medical Times*, ii., 1877). Certainly theory favors further trials of "pneumatic medicine," but we require more extensive experience before judging of its merits. Ducrocq, indeed, reports almost opposite conclusions to those of Burdon Sanderson (*Archives Générale*, September, 1876).

Mosso describes various anomalous results in the distribution of blood in the extremities under a pressure of two atmospheres, and explains them by changes in the innervation of the heart, or, with Paul Bert, by chemical, rather than by mechanical changes (*Medical Record*, 1879).

Workmen employed in making bridges, etc., under a pressure of two to three atmospheres, suffer from pains in the ears and joints, apparently due to "dilatation of superficial vessels," after leaving work. Among a large number of men no hemorrhage, heart disease, or serious disorder occurred (*Medical Times*, ii., 1877; cf. Moxon: *British Medical Journal*, i., 1881, p. 496).

Ozone.—Physiological Action.—Dewar and McKendrick pointed out the remarkable fact that, instead of the blood becoming more highly oxygenated under ozone-inhalations, it assumes venous characters in all the vessels, a fact which is explained by the greater density of this gas interfering with the due excretion of carbonic acid from the blood; it causes also some local irritation of the lining of the air-passages, and it induces slowing of the heart-action and respiration ("Proceedings of the Royal Society," 1873–74).

This was not in accord with previous observations, for Dr. Ireland had stated that ozone *quickened* respiration and circulation, excited the nervous system, and promoted coagulation of blood (*Edinburgh Medical Journal*, 1862–63, p. 729), but it is probable that his animals respired mainly oxygen. Day also had found that oxygen, "ozonized in proportion of one-twelfth, caused rapid respiration and heart-action, and much local irritation;" but quite recently Dr. John Barlow has confirmed and added to the observations of Dewar and McKendrick. He reports that ozonized air depresses the nervous system, probably through leading to accumulation of carbonic acid in the blood; it lessens the frequency of respiration, and hence also of heart-action, together with the excretion of carbonic acid and the absorption of oxygen. It irritates the pulmonary mucous membrane, and may cause bronchitis or lung-congestion (Redfern), or even asphyxia. It decolorizes the red corpuscles, and causes a granular appearance, probably from uniting with hæmoglobin; it stops

the amœboid movements of the white corpuscles, and renders the nucleus apparent; there is no evidence of its entering the circulation in a free state.

As illustrating its irritant effect, Dr. Barlow records its producing an obstinate inflammation of the nasal membrane (*Journal of Anatomy*, October, 1879).

THERAPEUTICAL ACTION (EXTERNAL).—*Ulceration—Gangrene.*—The gas has been applied in jet to atonic scrofulous ulcers by M. Demarquay, with much advantage.

Gangrene has been attributed by M. Raynaud to deficient oxygenation of tissue, and Langier and other French surgeons have recorded good results from its local treatment by oxygen (*Bulletin de Thérapeutique*, 1863–66). The destruction of tissue has been checked and limited, the swelling subdued, and the neighboring threatened livid tissue restored to its natural color. Dr. Goolden has recorded severe cases of phagedenic ulceration, especially one affecting the throat, which yielded to local application of oxygen, and he has recently written to renew his advocacy of this remedy (*Lancet*, i., 1866; ii., 1879).

THERAPEUTICAL ACTION (INTERNAL).—*Inhalation.*—Remedially, oxygen may be considered as it exists diluted in the atmosphere, or as prepared artificially for inhalation with a definite proportion of air.

Pure fresh air of the elevated country or the coast is of well-known efficacy in all conditions of debility, of chronic catarrh and chronic dyspepsia; sea-air especially contains more ozone than the air of land, and is of value to those who have lived in towns and followed sedentary occupations. On the other hand, patients with weak chests and readily congested lungs are better in a less rare and less ozonized atmosphere, since a large proportion of ozone may excite in them irritation of mucous membrane (Cornelius Fox). During epidemics of influenza an unusual amount of ozone has been verified in the air, while in cholera epidemics it has been almost absent. The choice of a climate for any given case is, however, generally influenced by other considerations than the mere amount of oxygen to be obtained; the subject need not, therefore, be fully considered in this place. The chief cases in which theory indicates, and experience justifies, the use of oxygen-inhalation, are those of asphyxia and of venous congestion occurring in the course of phthisis, asthma, or emphysema.

ASPHYXIA.—When this condition is induced by breathing noxious gases, the best results are obtained from oxygen. Sometimes a free current of fresh air is sufficient to restore persons rendered unconscious by an escape of gas or by the products of combustion retained within a room; but, in extreme cases, pure oxygen would seem the only means of saving life. Limousin has reported a case of asphyxia from carbonic acid inhalation, with intense cyanosis, which recovered under the use of oxy-

gen, and in which he was able to verify a steadily increased elimination of carbonic acid by the lung, in proportion to the oxygen taken (*Comptes Rendus, Société de Thérapeutique*, 1868). M. Constantin Paul has recorded many cases, including cyanosis from obstructed respiration, coma from opium-poisoning (when the respirations were only seven per minute), and asphyxia from carbonic oxide, all quickly and markedly relieved by oxygen (*Bulletin de Thérapeutique*, August, 1868). Rabuteau refers to an instance of its good effect in asphyxia from sewer-gas, when ordinary means, employed by M. Griscolle, had failed to relieve ("Éléments," p. 48); and finally I may quote a striking case recently reported by Dr. Charles B. Ball. A man, wife, and daughter, were found unconscious in a small room where there had been, through the night, a large fire, though the chimney was blocked. The two adults recovered with fresh air and ordinary means, but the daughter, aged sixteen (phthisical), remained unconscious and convulsed. After many hours of stimulating treatment she seemed to be dying; respiration was feeble and slow, the pulse imperceptible; then she was made to inhale pure oxygen, afterward oxygen and air. "The effects were rapid and marked:" respiration, color, and pulse improved, and though at first convulsed, she ultimately recovered. Dr. Ball, impressed by this case, and remembering Reynault's proof that man can live in an atmosphere strong in carbonic acid, provided that the proportion of oxygen is also increased, has contrived an apparatus with a reservoir of oxygen and a mask for safe use in dangerous mines. He has himself safely respired an atmosphere containing 18 per cent. carbonic acid with 30 per cent. oxygen added (*British Medical Journal*, i., 1878). If we compare the result in Dr. Ball's case with the fatal course of such cases of gas-asphyxia as, *e.g.*, may be found in the *Edinburgh Journal*, 1874, we shall better realize the importance of using oxygen in preference to other measures. In various forms of poisoning, whenever death threatens from asphyxia, as under prussic acid, chloroform, etc., artificial respiration, *i.e.*, supplying more oxygen, offers the best means of saving life.

Rosenthal and Leube found that the symptoms of strychnia-poisoning might be deferred or prevented by artificial respiration (Reichert's *Archiv*, 1867). H. Ebner thought the same result could be obtained by rhythmical movements of the limbs without supplying more air to the lungs, but Ananoff has since proved that pure oxygen is distinctly antagonistic to strychnia-action, and that when supplied to animals poisoned by this alkaloid it relieves them more than free access of ordinary air, or any movements (*Centralblatt für Medicin*, No. 27, 1874).

Asthma—Emphysema, etc.—The main suffering, the "besoin de respirer," common to these maladies, is clearly traceable to deficient access of oxygen to the blood in the lung-capillaries, and I am satisfied that in the majority of instances relief to this suffering may be given by sup-

plying a larger proportion of the gas. If it be objected that permanent good results are not obtained from it, the same objection may be made to many other remedies; it is still something to have a means at hand for temporary relief. Dr. John Hooper thus describes its effects in a man of fifty-five, "for many years a martyr to asthma." During a very severe paroxysm he was thought to be dying—it seemed impossible that he could rally. As a *dernier ressort*, oxygen was tried, the end of a glass retort containing it being applied to his mouth, though he had not power to enclose it with his lips. "The effect was wonderful and quickly manifest in increased mobility of the ribs, fuller inspiration, disappearance of lividity, and lastly in his seizing the end of the retort, and in the avidity with which he inhaled when possessing the voluntary power" (*British Medical Journal*, i., 1862). Details of diagnosis are not given in this instance, but paroxysms of true nervous asthma and of bronchitic asthma may both be shortened by similar inhalation. Beddoes related twenty-two cases, of which he claimed to have cured ten and relieved nine; and it seems worth while to refer to his case of "Mr. Hare, of Conduit Street, who, in 1796, after having been subject for eleven years to asthmatic attacks accompanied by indescribable suffering, and only relieved after many hours by blisters and expectorants," recovered average health under the use of the gas continued for some months (op. cit., 4th part, p. 49). M. Demarquay also witnessed excellent results, *e.g.*, in a man aged nineteen, subject from childhood to asthmatic attacks: "they ceased, as if by magic, as soon as he began to inhale oxygen ("Essai de Pneumatologie," p. 725).

Dr. Mackey has reported a good illustration of the value of the gas in advanced emphysema pulmonum (*Practitioner*, vol. ii., May, 1869). A lady, aged fifty-five, was subject to constant dyspnœa, increased by every movement, and amounting at times to partial asphyxia. She had the physical signs of the malady, together with dilated weak heart and embarrassed circulation, as evidenced by œdema of the face and extremities; was subject to attacks of bronchitis, but at the time of treatment the main complaint was the difficulty of breathing. She inhaled a mixture of from three to twelve pints of oxygen, with sixty of air, at intervals of three or four days, for a period of six weeks. After each dose "marked relief was experienced, which she expressed as being able to take a deep breath and get sufficient air (a feeling not known for years), as being able to move with comparative ease, feeling more buoyant and more like healthy persons should feel than she ever remembered." Expectoration was rendered more copious and facile for a day or two after the inhalation; there was no other definite effect on secretion, nor any on circulation, unless it were some palpitation during the night after a large dose. The nervous irritable states to which such patients are liable were also soothed under the treatment, which certainly effected more than ordinary medicinal agents.

It could not, however, alter the organic conditions, and cardiac death occurred suddenly, after an attack of bronchitis, in the following winter.

These illustrations seem to me sufficient to prove that oxygen might be used more often than it commonly is in such cases. According to Biedert's method, emphysema is treated by a few short sittings of respiration in *compressed air*, and then by expirations into an atmosphere of *rarefied air*, "in order to counteract anæmia by attracting blood toward the lung-tissue."

In *Bronchitis*, bronchial catarrh, and bronchial asthma, *compressed air* is used to stimulate the lung, improve its circulation, and facilitate expectoration ; it seems to be useless during actual asthmatic attacks. In mitral disease it is said to be valuable, and in dyspnœa dependent on dilatation of the right heart.

Pleuritic Effusion—Empyema.—I have used oxygen in several of these cases with good results. During inhalation relief to breathing was experienced, which lasted for some time afterward; compressed air has also been employed for these disorders. Biedert reports two cases of pleuritic adhesion in which vital capacity was much increased by it, and Kelemen one of empyema in which the effusion disappeared as diuresis set in (*Medical Record*, August, 1879).

Whooping-Cough.—Moutard-Martin says that compressed air baths are efficient in this complaint (*Union Médical*, March 11, 1879).

Phthisis.—The true value of oxygen-inhalations in this disease has been the subject of much discussion. So early as 1783 it was tried with apparent good result, and Fourcroy was appointed by the French Government to report on the subject. After examining into twenty cases he concluded that almost all patients benefited, for a time at least, by the treatment, but relapsed and got worse more rapidly and with more inflammatory complication than if oxygen had not been used ("Sur les Propriétés Médicinales de l'Air Vital," 1789).

It is evident that to establish such a conclusion very careful observation is required, and more precision than the then art of diagnosis could attain; but the opinion exercised considerable influence at the time, was adopted by Dr. Beddoes and some other observers, and was one reason why this method of treatment fell into a disuse which was not altogether deserved.

Among modern writers, Dr. Birch, Constantin Paul, and Demarquay have reported relief in cases of phthisis, and the following occur among others related by Dr. Mackey. Mrs. W., aged thirty-one, of phthisical family, when first seen had had, for six months, cough, emaciation, and latterly diarrhœa, night-sweating, hectic, hæmoptysis, and purulent expectoration ; much chest-pain ; there were dulness and crepitation at left apex. After some months of treatment of the usual recognized kind, she

improved, and complained mostly of debility, cough, pain, expectoration, and dyspnœa. She commenced oxygen-inhalations (six to twelve pints in sixty). After eight inhalations, at intervals of two days, all these symptoms were markedly better, and treatment was omitted. The malady was arrested for a time, but, after exposure to poverty and misfortune, this patient died one or two years later.

R., aged nineteen, with family history of phthisis, after partial recovery from acute softening of the right apex, commenced inhalation as a remedy for dyspnœa and pain in the chest, and at the end of two months was sufficiently recovered to resume the sedentary work of a clerk. It should be stated that iron and cod-liver oil were given throughout, but the patient distinguished definite relief to his breathing from the use of the gas. He was in fair health six months afterward, when the case was reported, but he died within eighteen months, of acute phthisis following imprudent exposure.

A third patient, a man aged thirty-four, commenced inhalation while still suffering from acute symptoms dependent on softening tubercle, and continued it for nearly three months, with marked improvement as to breathing-power, cough, expectoration, and appetite. In this case the end came by pneumonia and pleuritic effusion, but after a prolonged exposure to bad weather, and independently of the treatment.

Such cases in themselves do not show more than a temporary relief of symptoms, and at least no harm from the gas, and they are really too few for any conclusions. A larger number are given by Dr. A. H. Smith ("New York Prize Essay"), and his general results are so far favorable as to warrant still further trials with this agent. I would except from its use cases of very acute character, and of hæmoptysis, in which, indeed, the mere exertion of inhaling would contra-indicate it. In other cases benefit may be hoped for, not so much through any local action on the lung-tissue as through improvement of the blood-condition, the appetite, and the power of assimilation; nor, speaking from experience, do I believe that oxygen, used with ordinary care and in such dilution as has been mentioned, can at all irritate or inflame the lung-tissue.

Dr. Read (Long Island) has reported a series of twenty cases treated by inhalations of oxygen in *conjunction* with cod-liver oil. The majority did well, and he reports it "an admirable adjuvant to the usual routine treatment of phthisis, especially when the patients were unable to go out of doors." He gave the gas also in acute pneumonia, and apparently with advantage. The use of compressed and rarefied air seems rather to alleviate symptoms than to cure phthisis. In pretubercular stages it may serve to strengthen the respiratory muscles and open out the chest, but it is not suitable for acute or hemorrhagic cases, or those with a large area of congestion.

Hepatic Congestion.—Dr. Birch has advocated the use of the gas in

this condition, and states that it will relieve the constipation and other symptoms connected with it. The remedy has no doubt been of service, especially in cases with much headache, depression, loss of appetite, and sense of pain and constriction about the shoulder and chest, with palpitation and dyspnœa. In some chronic cases in which it was tried I have not seen benefit, and, as a general rule, medicinal and dietetic treatment, with such oxygen as is obtained by increased *exercise*, will give at least more rapid results.

Chlorosis—Anæmia.—Beddoes relates many instances of chlorosis benefited by inhalations, but other observers have not met with equal success from its use in this malady. I have, however, known it to relieve chlorotic headache. In extreme cases of anæmia the gas is not always well borne; it has seemed sometimes to increase depression for the time, and cause faintness and palpitation.

Diabetes.—Pettenkofer and Vogt determined that diabetics absorbed less oxygen than healthy persons, and that hence we might hope, by introducing more into their system, to obviate some conditions of their malady.

Bouchardat, and also Demarquay, have recorded cases relieved by this treatment, but no extensive trial of it has been made. Peroxide of hydrogen has been given internally with the same object—of oxygenation—and with some partial success.

I have tried oxygen-inhalation in several cases of diabetes in which prostration, dyspnœa, and tendency to cyanosis were prominent symptoms —one case was at the very unusual age of seventeen months, another at thirteen years, and three others at adult age. The gas certainly relieved for a time the symptoms mentioned, although it did not in any instance reduce the sugar in the urine.

Albuminuria.—In a few cases of Bright's disease, narrated by Dr. C. Paul, albumen disappeared from the urine during treatment by oxygen. This occurred also in the often-quoted case observed by Kollman and Eckart (Schmidt's *Jahrb.*, 1865). More recently, Dujardin Beaumetz reports a case "in the last stage," and in which every diuretic had proved useless, and yet, twenty-four hours after inhaling oxygen, the albumen disappeared, and was still absent twelve days afterward when the case was reported (*Medical Record*, March, 1879). Other physicians, while recording similar cases in their own experience, stated that the good result was not of long duration.

Nerve Disorders.—A few cases of severe neuralgia relieved by oxygen are on record (Birch, J. Hooper: loc. cit.), and it has been praised in spinal palsy, nerve debility, and hysteria, but I think without sufficient reason. What little trial I have made of it in such cases has not given me any good result.

Dr. Ramskill has reported a case of epilepsy apparently relieved by

the gas, which he gave by inhalation from peroxide of hydrogen (*Medical Times*, i., 1863).

Hydrophobia.—Drs. Paul and Josias used oxygen in this malady, and, although the patients died, some relief was given to the symptoms of asphyxia. Recently Dr. Schmidt has recorded the case of a girl, aged twelve, who, when recovering from diphtheria, was bitten by a mad dog; seventeen days afterward she had difficulty of breathing and of swallowing, and oxygen-inhalation relieved her; she relapsed next day with convulsions, spasms of respiratory muscles, and unconsciousness; oxygen again relieved her, and, after some complications traceable to the diphtheria, she ultimately recovered (*Medical Record*, 1878).

Tetanus—Strychnia-Poisoning.—Richardson refers to some cases of tetanus, under Sir J. Paget, much relieved by oxygen-inhalation; the patients became bathed in perspiration, and the muscles relaxed. He insists also on its importance in strychnia-poisoning in conjunction with amyl nitrite, as unless elimination be promoted by oxygen, the spasm, even if relieved, soon returns. "Oxygen is a remedy for all excess of nerve-action leading to spasm" (cf. p. 12).

Mode of Administration.—M. Demarquay obtained his oxygen from chlorate of potash, and made use of caoutchouc bags, which were filled with the washed gas and could be carried to the patient's bedside. M. Limousin has introduced a small portable apparatus with brass retort, wash-bottle, and caoutchouc bag, so that the gas can be prepared and used on the spot; but in this country the most available method is that of Mr. Barth, of Bloomsbury: he supplies a small gasometer, with the gas condensed under high pressure into iron bottles, from which a measured quantity can be introduced and mixed in definite proportion with air, and then inhaled in the usual way. This method leaves nothing to be desired. The patient should be quiet for a time before and after inhalations, and not be over-fatigued; the stomach should be neither full nor quite empty; the feet should be warm, and the circulation equable. Other modes have been devised for introducing oxygen into the system, as by oxygenated water and oxygenated bread, but I have no confidence in these preparations. A method still open to investigation is the administration of peroxides, especially those of hydrogen and of iron, and of chlorate or permanganate of potash (*v.* Potash); and some experiments of C. Bernard warrant the conclusion that these compounds give up to the blood a proportion of their oxygen, and are eliminated in a less oxidized condition.

Contra-Indications.—I have not met with any case wherein oxygen, more or less diluted, was indicated, and could not be safely used. If organic heart disease be present, care should be taken to regulate the force and the effort of inhaling, which sometimes gives rise to giddiness or palpitation independent of the remedy. Some soreness of the throat, and

temporary discomfort about the mouth, may occur if the apparatus be not quite free from dust; but from the gas I have seen no bad results whatever. The contra-indications to the use of compressed air are degeneration of vessels and an apoplectic tendency; to that of rarefied air, pulmonary hemorrhage.

NITROGEN, N,=14.

This gas is very widely diffused, constituting 76.99 per cent. by weight of the atmosphere, 79.19 per cent. by measure. In combination, it occurs in the mineral kingdom as the basis of nitrates, nitrites, etc., it enters into the composition of almost all *animal* tissues, and in the vegetable kingdom it is found as a constituent of the alkaloids and the most active medicines, as well as of the most nourishing foods.

Preparation.—Nitrogen may be obtained by burning either phosphorus or a mixture of iron filings and sulphur, or certain other substances, in a limited quantity of air, as under a bell-jar: the oxygen will be taken up and only nitrogen left. The process is not an easy one, and hence, possibly, the little trial so far made of the gas in medicine.

Characters.—A colorless, odorless gas, sp. gr. .975, soluble in water to some extent.

Physiological Action.—This is negative in character; the gas will not support respiration ("azote") nor combustion, and it seems to act in the atmosphere as a diluting agent for the too stimulating oxygen. M. Demarquay injected nitrogen into the peritoneum and cellular tissue of animals, and came to the conclusion that more or less exhalation from the lungs, etc., of the normal gases of the blood was caused by it (*Archives Générales*, 1859).

Therapeutical Action (External).—On the hypothesis that the stimulation of ordinary air caused irritation and suppuration in wounds, stumps, etc., M. Demarquay was led to try the effect of enclosing them in caoutchouc bags full of nitrogen; but the practice was not successful.

Therapeutical Action.—Inhalation.—It has been proposed to utilize nitrogen by adding a larger than normal proportion of it to ordinary air for inhalation in irritable and inflammatory lung-condition, but no definite results have been obtained in this country. Steinbrück (Vienna) has, however, lately recommended nitrogen-inhalations in the first and second stages of phthisis in young persons, stating that "they lower the circulation and allay nerve-irritability, give great relief, and sometimes cure;" in the third stage they are injurious (*Dobell's Reports*, 1876). I have not seen any confirmation of these results. The power of nitrous oxide as an anæsthetic has been largely developed in recent times (*v.* Anæsthetics).

HYDROGEN, H,=1.

Hydrogen, being the lightest of known elements, is commonly taken as a standard of specific gravity and combining proportion. It has been found free in small proportions in certain volcanic gases, and occurs extensively in combination, *e.g.*, in water, in many acids and gases, in hydrocarbons, and all substances used for artificial light—tallow, oils, coal-gas, etc.—and throughout the vegetable kingdom. It was formerly known as "inflammable air," and when lighted burns with a bluish flame.

PREPARATION.—By acting on granulated zinc with dilute sulphuric or hydrochloric acid—$Zn+H_2SO_4=ZnSO_4+H_2$

CHARACTERS.—A colorless, inodorous gas, of sp. gr. 0.0692.

PHYSIOLOGICAL ACTION.—This is negative in character. Hydrogen does not support respiration or combustion, and Priestley ascertained that animals immersed in it died as soon as in carbonic acid. Beddoes found that attempts to inhale it caused cyanosis of lips and face, quickness and smallness of pulse, vertigo, impaired vision, and in some persons, drowsiness, slight insensibility, and when pushed, asphyxia in greater or less degree. A mixture with oxygen, when inhaled, causes the voice to become shrill.

THERAPEUTICAL ACTION.—Dr. Beddoes used hydrogen gas as an inhalation in phthisis, both by itself and in mixture with oxygen. He reported some cases as relieved and others cured, but his results have not been corroborated. The most constant effect seems to have been the production of sleep.

HYDROGENII PEROXIDUM—PEROXIDE OF HYDROGEN, H_2O_2,=34.

PREPARATION.—By acting on barium peroxide with hydrochloric acid.

CHARACTERS.—This compound of hydrogen is a liquid of the consistence of syrup, of strong, disagreeable, metallic taste, very unstable, and readily parting with its oxygen; hence, it is a powerful oxidizer. It blanches a solution of litmus. A solution, of sp. gr. 1,006, is in common use abroad for bleaching purposes, and is said to be permanent.

PHYSIOLOGICAL ACTION (EXTERNAL).—This liquid, applied locally, whitens the skin and mucous membranes, and acts as a moderate caustic. It has also marked antiseptic power, though not equal to carbolic acid in that respect. Urine mixed with one-tenth of peroxide remained nine months without putrefying (Guttmann). The patent disinfectant termed "Sanitas" is said to depend for its efficacy mainly upon this peroxide.

PHYSIOLOGICAL ACTION (INTERNAL).—It produces, when given internally, some oxidizing, stimulating, and, in full doses, irritant effects. The bleaching solution, of sp. gr. 1,006, has been used by Assmuth, Schmidt,

and Guttmann for hypodermic injection in animals, and found to cause dyspnœa, clonic convulsions, and death in a few minutes from asphyxia. The last-named observer traces this to the development of bubbles of gas in the right cavities of the heart, the blood frothing up as if air entered by the veins. The result is partially antagonized by injection of ferrous sulphate, implying the combination of this with part of the oxygen liberated (Abstract, *Medical Times*, ii., 1878).

THERAPEUTICAL ACTION (EXTERNAL).—*Ulcerations.*—Lotions containing peroxide have been used with advantage in soft chancre and in cases of fetid ulcerations of the mouth.

THERAPEUTICAL ACTION (INTERNAL).—*Chronic Dyspepsia.*—Richardson, Guttmann, and others have reported improvement of the digestion under this remedy, but it is not much used.

Diabetes.—Cases of this disorder treated successfully by peroxide of hydrogen have been recorded (*British Medical Journal* and *Lancet*, 1868), and much good was at one time expected from it as an oxidizing agent; but Dr. B. W. Richardson, who introduced the remedy and used it in more than two hundred cases, came to the conclusion that, although it could reduce the specific gravity of the urine, it at the same time increased its quantity, and had no really good effect (*Medical Times*, ii., 1868). Dr. Pavy tried it in a few cases without any result ("On Diabetes," p. 268).

Cyanosis—Pulmonary Congestion (*Passive*).—In these conditions, where oxygenation of the blood is defective, and which are generally connected with heart disease, I have sometimes seen advantage from the internal use of peroxide of hydrogen—it is worth trial, but further observations are needed for estimating its true powers. Dr. B. W. Foster has reported two cases of congenital cyanosis relieved by it ("Clinical Medicine," 1874).

Phthisis—Struma.—I have no personal experience of its use in these diseases, but benefit has been reported from it. In early stages it is said to improve digestion, in later stages to relieve dyspnœa, and in struma to cause absorption of glandular swellings (Ranking, 1868).

Pertussis.—Much power has been claimed for peroxide of hydrogen in the relief of paroxysms of whooping-cough, but I have no experience of it. In a severe case, complicated with cyanosis, in a child with patent foramen ovale, Dr. Mackey used the remedy with apparently good result for the time; the degree of cyanosis was less while the remedy was taken, and the attack of pertussis ran a mild course.

PREPARATIONS AND DOSE.—A solution containing ten volumes of oxygen is the one recommended by Dr. Richardson; an ethereal solution is preferred by others. Dose: of the former, 1 to 4 dr. freely diluted; of the ethereal solution, ½ to 2 dr.

CARBO, CHARCOAL, C,=12.

Carbon is very widely distributed throughout all the kingdoms of nature; the diamond represents its purest condition, crystallized in the form of a regular octahedron. *Plumbago*, or *graphite*, the "black lead" of our pencils, is another form which is nearly pure, and is sometimes crystalline. This element, combined with oxygen and various earths and minerals, forms carbonates, as chalk and limestone, and combined with oxygen it occurs as carbonic acid in the air and in many mineral waters. Two varieties of carbon are now officinal, in the form of charcoal prepared from wood and from bones.

CARBO LIGNI—WOOD CHARCOAL.

Preparation.—By burning wood in covered heaps or in closed vessels, in such a manner as to almost entirely prevent the access of air. The oxygen, hydrogen, and nitrogen of the vegetable substance are driven off, and about 20 per cent. of carbon remains, with a small proportion of earthy salts—carbonates of potash and lime, etc. A pure charcoal may be obtained from the combustion of oils or resins with insufficient oxygen, and is known as lamp-black. For medicinal use, either kind may be further purified by ignition in a closed vessel to a red heat.

Characters.—Wood charcoal occurs as a black powder, or in black, brittle pieces, very light, and retaining the shape and texture of the original wood. It is distinguished from purified animal charcoal by leaving a bulky, white mineral ash, which is the 1 or 2 per cent. of mineral salt.

CARBO ANIMALIS—ANIMAL CHARCOAL—BONE-BLACK.

Preparation.—By exposing the bones of animals to a red heat without access of air. Thus prepared, it contains 10 to 20 per cent. of charcoal, the remainder being mostly phosphate and carbonate of lime, with some iron sulphuret. It may be obtained from any animal substance, a good quality being procured from dried blood.

CARBO ANIMALIS PURIFICATUS—PURIFIED ANIMAL CHARCOAL.

Preparation.—By digesting the commercial charcoal with dilute hydrochloric acid for two days in a warm place; filtering, washing, drying the residue, and igniting in a closed crucible. By these processes the salts are rendered soluble, and removed as superphosphates and soluble chlorides, while carbonic acid and sulphuretted hydrogen gases are driven off.

Characters.—It occurs as a smooth, black powder, which has no odor and scarcely any taste; when burned it leaves very little ash. Charcoal has certain chemical and mechanical properties which are very useful in pharmacy. That prepared from wood is used as a deoxidizing agent, as in the preparation of sulphurous from sulphuric acid (by distilling the latter with it), and the reduction of iodate to iodide of potassium. Animal charcoal is used as a decolorizer in the preparation of alkaloids, etc. Its power in this respect is such that diluted tincture of litmus will filter through it colorless. Warrington ascertained that it would remove the bitterness of hops and other vegetable infusions, and Dr. Garrod soon afterward pointed out that it would destroy the activity of many organic poisons, as opium, aconite, and nux vomica (*Lancet*, ii., 1845). Animal charcoal is much more powerful as an antidote than that prepared from wood.

Both varieties possess great absorptive power, taking up more than twice their weight of gases, and may be used for purifying water by filtration, and for the disinfection of sewer-emanations, and the deodorizing of sick-rooms, dissecting-rooms, etc. (Letheby). A respirator containing a layer of charcoal has been recommended (Stenhouse, Marcet).

Therapeutical Action (External).—*Fetid Discharges.*—Charcoal is used in surgery to cleanse and alter the condition of old and sloughing ulcers, suppurating sores and wounds, and is sometimes applied directly to them in the form of powder, or poultice with bread; to relieve offensive odors it is better enclosed dry in muslin bags and placed near the wounds. In open cancer a paste of soot with glycerin is said to be a useful application (Debreyne: *Medical Times*, i., 1860, p. 402). For offensive perspiration of the feet or axillæ, charcoal may be mixed with alum or zinc oxide, and used as a dusting powder; with chalk it forms a cleansing dentifrice.

Cautery.—Charcoal "pegs" have been used as a cautery; they are mixed with nitrate of potash (*Lancet*, ii., 1866, 309).

Therapeutical Action (Internal). For ordinary medicinal use, wood charcoal is commonly preferred.

Dyspepsia, Flatulence, etc.—It is very useful for patients suffering from pain, weight, and sense of fulness at the epigastrium with flatulent distention, acidity, sour or bitter eructations, nausea or vomiting, furred tongue, foul breath, and with a tendency to loose, ill-formed motions. These stomach symptoms are usually accompanied with palpitation.

The charcoal powder, which acts by absorbing intestinal gases and neutralizing offensive products of decomposition, should be perfectly fresh and taken dry, and preferably at the commencement of a meal. The dose need not be so large as a teaspoonful, which is commonly given; in many cases I have found 2 to 5 gr. sufficient. Bismuth and magnesia are sometimes advisable at the same time.

Diarrhœa.—Charcoal acts well in the diarrhœa of scrofulous children when the stools are small, slimy, and light-colored, with intermediate troublesome discharge of flatus and itching of the anus; also when the attacks have depended upon irritation of the mucous membrane from undigested food, etc. It may be well given with milk (cf. *Medical Record*, March, 1881). Rhubarb is often usefully combined with it in the cases described.

Charcoal is also serviceable in the atonic irritative diarrhœa of old people, but I have more than once known intestinal hemorrhage occur after its use. If large quantities be given, some may be retained and act as a mechanical irritant, so that the remedy is not so innocent as commonly thought.

Dysentery.—Charcoal has been recommended in dysentery, and its antiseptic powers may be serviceable in chronic cases. The putrid smell of the discharges may certainly be relieved by a few doses of 30 to 60 gr., but it returns on discontinuance of the remedy; the effect is a temporary chemical one.

Dr. Farre has reported cases in which it has acted equally well when given in enema (Ranking, ii., 1862).

In *Enteric Fever* charcoal lessens the distention of stomach and intestines, and when mixed with magnesia sometimes proves still more beneficial.

Cancer of Stomach—Gastric Ulcer.—In these organic diseases many of the distressing symptoms may be relieved by charcoal.

Ascarides.—A daily dose of charcoal mixed with salt, and given in the early morning, has been found useful in destroying and preventing the development of these parasites.

Preparations and Dose.—*Of wood charcoal*, many varieties are in use, some practitioners giving the preference to that made from heavy woods (box, acacia, etc.), others to the light woods (poplar or willow). Dr. A. Leared recommended that made from "vegetable ivory." Charcoal from the hæmatoxylon campechianum is good, but has been overpraised. Belloc's is also a good preparation; it is made from poplar. Biscuits and lozenges of charcoal are also used, but in my experience are not so effective as the powder, and they sometimes irritate the stomach. *Carbo ligni:* dose, as antacid, antiseptic, or absorbent, 10 to 60 gr., or more. *Cataplasma carbonis* ("charcoal poultice") contains ½ oz. of wood charcoal. *Carbo animalis* is to be preferred as an antidote to poisons: dose, from ½ oz. to 2 oz. or more, according to the amount of poison swallowed; it is best taken suspended in water. *Carbo animalis purificatus:* dose, 20 to 60 gr. or more.

[Preparations, U. S. P.—*Carbo animalis, Carbo animalis purificatus*, and *Carbo ligni.*]

SULPHUR, S,=32.

This element occurs in the animal kingdom as a constituent of the albuminous (protein) tissues, of bile, of cystin, etc., and in the vegetable kingdom in many essential oils and resins, such as those of mustard, horse-radish, garlic, and asafœtida. In volcanic districts it is found native, and in many places it is met with combined with metals, as sulphide, or "pyrites"; the bisulphide of iron contains more than half its weight of sulphur. United with hydrogen or with alkalies, it is found in many organic substances and mineral waters, and with oxygen it forms sulphuric acid and the various sulphates.

Characters and Tests.—Sulphur occurs in commerce either as a gritty powder, or in round sticks (roll sulphur—brimstone), or in crystals; it is opaque and brittle, pale yellow in color, of insipid taste, and emitting a peculiar odor if it be rubbed; it is inflammable, burning with a bluish flame and evolution of sulphurous acid gas. Sulphur melts at 115° F.; at greater heats it becomes amber-colored, then brown, and gradually thickens until the containing vessel may be inverted without spilling it; it is insoluble in water, slightly soluble in alcohol (absolute alcohol dissolves nearly 1 per cent.), partially soluble in fixed and volatile oils and bisulphide of carbon. Hydrochloric acid added to sulphur or its compounds causes evolution of sulphuretted hydrogen, which will be known by its characteristic odor.

Officinal Forms.—Two varieties of sulphur are placed in the Pharmacopœia—the sublimed and the precipitated.

SULPHUR SUBLIMATUM—SUBLIMATED SULPHUR—FLOWERS OF SULPHUR.

Preparation.—By melting or burning the native sulphur-earth, or any metallic sulphide, and condensing the vaporized sulphur in large chambers.

Characters.—Sublimed sulphur is a gritty powder, canary-yellow in color, and possessing the characters of the element as already described. It may be acid in reaction from the presence of a little sulphuric acid, formed by slow oxidation, and should be freed from this by washing with distilled water, after which it becomes "sulphur lotum."

SULPHUR PRÆCIPITATUM—PRECIPITATED SULPHUR.

Called also lac sulphuris (milk of sulphur), though this name was originally given to an old preparation made with lime sulphate.

PREPARATION.—From the sublimed sulphur, by first boiling it with slaked lime until the substances combine, and then adding hydrochloric acid, which unites with the lime while the sulphur is precipitated.

The reactions are somewhat complex, but may be thus represented: $3CaH_2O_2+6S_2=2CaS_5+CaS_2H_2O_4+2H_2O$ and then, on adding the acid, $2CaS_5+CaS_2H_2O_4+6HCl=3CaCl_2+4H_2O+6S_2$.

The precipitated sulphur should be dried at a heat of 120° F.

CHARACTERS.—A pure specimen is of pale dead-yellow color, without odor or taste, very smooth to the touch, not readily diffused in water. Under the microscope it presents opaque rounded granules, separate or in clusters.

[SULPHUR LOTUM, U. S. P.—*Washed Sulphur.*—Sublimed sulphur, thoroughly washed with water. It is wholly volatilized by heat, and, when moistened with water, does not change the color of litmus.]

SULPHIDES OR SULPHURETS.

Sulphurated potash (hepar sulphuris, or "liver of sulphur") (*v.* Potash) and *sulphide of calcium* (hepar calcis, or "liver of lime") are in common medical use, and the sulphides of sodium and of ammonium are found in many of the sulphurous mineral waters. Their action is somewhat similar to that of sulphur, perhaps more powerful. The *sulphide of calcium* (not officinal) is found native, or may be prepared artificially by calcining, in a closed vessel, equal parts of sublimed sulphur and pulverized oyster-shell (a pure form of lime carbonate). It is a yellowish white powder of sulphurous taste and odor. *Hypochloride of sulphur* consists of "flowers of sulphur" impregnated with a small quantity of chloride of sulphur (S_2Cl_2) obtained by passing chlorine over sulphur. It is apt to explode if kept in full glass bottles closely corked.

ABSORPTION AND ELIMINATION.—It has been stated, though not satisfactorily proved, that finely divided sulphur may pass as such into the blood. Eberhard states further that he has seen it in the lymphatics, and Griffith that he has found it excreted in the urine, but these statements lack confirmation, and are not easy of credence.

It is more probable that, before absorption, under the influence of alkaline saliva and mucus, and the secretion of intestinal glands, an alkaline sulphide is formed, part of which is decomposed in the intestine (the resulting sulphuretted hydrogen being passed as flatus), and part oxidized, since its administration increases the urinary sulphates (Regensburger: *Centralblatt f. Med.*, 1877). Of any ordinary dose of sulphur, a certain proportion passes out unchanged and unabsorbed in the fæces. Fatty substances are said to promote absorption of sulphur, though the experiments of A. Krause (1853) scarcely support this view. He found that

when equal doses of sulphur were given, either with or without fat, the amount of sulphates excreted by the urine was the same.

The sulphuretted hydrogen which is absorbed is eliminated by the skin, the bronchial membrane, and by the various glands, and gives indication of its presence, both by its odor and by staining silver articles worn about the person. Orfila detected it in the urine.

In exceptional cases the gas may be formed in, and absorbed from, the intestine with production of marked but temporary nerve-depression. I have not myself seen this *as an effect of taking sulphur* medicinally, and in cases where sulphuretted hydrogen has been injected into veins it has been so quickly eliminated by the lungs that the arterial current remained unaffected by it (C. Bernard). Dr. B. W. Richardson concluded, from observations with "sulphur alcohol," that its compounds were *not* absorbed from the alimentary canal, but I believe that occasionally they may be so. In aged persons, and in some cases of hepatic and intestinal disorder, I have noticed attacks of depression coincident with flatulence and foul breath, and relieved by a stimulating purge; and Dr. Senator has recorded the case of an adult suffering from gastric catarrh, in whose breath and urine sulphuretted hydrogen had been detected, and who had more than one attack of collapse lasting for a few minutes and accompanied with pallor, giddiness, and small, quick pulse; he recovered after purgation (*Berlin. klin. Woch.*, 1868, No. 24).

Physiological Action (External).—Applied with friction to the sound skin, sulphur causes a moderate degree of irritation; much more if the surface be excoriated. The alkaline sulphurets, such as those of potash and of lime, irritate severely, if used in strong and warm solution, to a delicate skin. Sulphur and some of its compounds have the power of destroying the lower forms of vegetable and even animal life; whence their practical value as "anti-zymotic and anti-parasitic" remedies. Binz attributes this power to the formation of *sulphurous acid* under the influence of exposure to the air, and to heat, and to contact with protoplasmic organisms (*e.g.*, the oïdium Tuckeri of the grape). The subject of disinfection is more fully considered under the heading of Sulphurous Acid.

Physiological Action (Internal).—Given to animals it produces at first, at least, some stimulant effect. Benk states that its after-effect is of reverse character, and that this is accompanied by, and is probably due to, intestinal irritation. Hertwig found also that animals were readily brought under the influence of the drug with production of diarrhœa.

Circulatory System.—Sulphur and the sulphides, in moderate doses, stimulate the circulation, especially that of the capillaries, the skin and mucous membrane, and the venous circulation within the pelvis. Congestive headache, vertigo, and sometimes hemorrhage have been traced to the use of the drug and of mineral waters containing it. Gubler, Mit-

scherlich, and many older authorities are agreed upon these points, and assert further that a rise in temperature and distinct pyrexia may be caused by sulphur, especially in plethoric persons.

Secretion and Excretion.—Buchheim and some modern writers express doubts as to whether sulphur really increases secretion from the bronchial mucous membrane and the skin; but I cannot agree with them, for I have frequently seen an augmentation of these secretions under the use of this remedy. According to Boecker the urinary water and solids are increased in amount under the action of sulphur, but this requires confirmation (Husemann).

Cutaneous System.—Some dark coloration and much irritation of the skin may occur from the internal use of sulphur. I have seen a red papular eruption from it, and also occasionally boils and carbuncles. The waters of Harrogate, Baréges, Aix-la-Chapelle, etc., have been known to produce such effects.

Digestive System.—The *sulphides*, in small doses, excite a sensation of warmth at the epigastrium; in excessive doses, they may cause gastro-enteritis, and even, it is said, "insensibility and speedy death" (Ringer). Sulphur itself in small doses excites a similar sense of warmth, sometimes gaseous eructations; sulphurous waters in the quantity of several ounces often cause pain and oppression in delicate subjects. Doses of 20 to 40 gr. and upwards of sulphur in powder cause moderate stools, semi-solid in character, and passed with perceptibly increased peristaltic action; hence, it has been presumed that the muscular coat is mainly acted upon. Sundelin maintained that sulphur had a "specific" action on the mucous coat, but we cannot speak positively about this (Binz). The prolonged use of sulphur as an aperient induces intestinal catarrh.

Husemann supports the view that unabsorbed sulphur mechanically protects the intestinal mucous membrane like bismuth, and this would explain the fact that large doses relax without colic, while moderate doses relax equally, but with some colic, and small doses cause pain without the relaxation.

Synergists.—As a stimulant, sulphur is aided in effect by the volatile oils; as an alterative, it has analogies with arsenic, phosphorus, and possibly iodine (Gubler); as an aperient, magnesia and the acid tartrate of potash assist its action.

Chemically, sulphur belongs to the same group as oxygen, selenium, and tellurium, and between oxides and sulphides there is much analogy.

Antagonists.—Sedatives, refrigerants, astringents, and cold oppose the ordinary action of sulphur; quinine and bromides have a specially antagonistic effect.

Therapeutical Action (External).—*Parasitic Skin Diseases—Scabies.*—Sulphur is one of the substances which are fatal to acari, and it still remains one of the best, as it is the commonest, remedy for sca-

bies, though Dr. McCall Anderson and others have objected to it as too irritant.

It is nearly certain that sulphur, when used by itself or mixed with lard, has simply a mechanical effect on the epidermis; but when carbonate of potash is added to the ointment, *sulphurated potash* is formed, and this compound quickly destroys the acari. We know, from clinical observation, that these insects often live in the plain sulphur ointment for several days without much apparent detriment, while, as Kuchenmeister says, "the acari, kept in a solution of sulphurated potash, die in a quarter of an hour."

The strength and the frequency of the application should be varied according to the delicacy of the patient's skin and the amount of the eruption; the more active the preparation, and the more thorough its use, the quicker will be the cure. Thus, painting the body with a solution of chloride of sulphur in sulphuret of carbon is said to cure in five minutes (*Medical Times*, i., 1856, pp. 247, 368); while Bourguignon's formula with lime and sulphur (boiled together) is allowed half an hour, and M. Hardy's method with soft-soap frictions, warm bath, and anointing with 2 parts of sulphur to 8 of lard and 1 of potash carbonate, effects its purpose in four hours (*British and Foreign Review*, ii., 1852, Leçons); but such results are liable to be accompanied with unnecessary irritation and pain to the patient. Dr. Tilbury Fox, having seen eczematous eruptions and chronic irritation often induced by the excessive use of too strong an ointment, and founding his advice on observation of the parts usually affected, advocates the use of a mild ointment (1 part in 16, *i.e.*, ½ dr. to the ounce of lard) *to the wrists and between the fingers only*, in acute cases accompanied with general irritation (*Lancet*, ii., 1871); but, as Hebra and R. Liveing observe, the restriction of the application to a *few portions* needs very exact diagnosis, and, as a rule, the ointment of the selected strength should be applied to every part. A prolonged warm bath (half-hour), and thorough cleansing with soap and friction, should precede the inunction; then, after drying, either the mild ointment of Fox, or the simple ointment of the Pharmacopœia (1 part in 5), or one of intermediate strength (1 part in 8, with ½ a part of potash carbonate) should be plentifully rubbed over the trunk and the limbs, especially the flexor side of the limbs and between the fingers and toes; and then socks, gloves, drawers, and jersey should be used to keep the ointment in contact with the skin (Liveing). An ointment I commonly prescribe is made with sublimed sulphur, 2 dr.; sulphide of calcium, ½ dr.; and simple ointment, 2 oz. After a night's application, a warm bath in the morning may be used to remove the odor of sulphur, but then a second or third inunction may be required; if the first one can be left undisturbed for twenty-four hours, it will often suffice to cure. In some cases, a lotion of sulphuret of calcium (liquor calcis c. sulphure) acts better, because it is

more thoroughly applied than an ointment; its use should also be preceded by a warm bath, and it need only be *gently* applied with a sponge or brush; if used with friction it may cause very severe irritation.

A sulphur-*bath* is not so effacious as these remedies, but may sometimes be required, and may be made with half a pound of sulphurated potash to thirty gallons of water—or with sulphur, hyposulphite of soda, and acid (*v.* Preparations). Wooden or porcelain vessels should be used for the baths, of which several will be required. Sulphur in vapor may also be employed.

It is important to remember that irritation of skin may remain even after the scabies itself is cured, and this irritation is to be treated by soothing remedies; sulphur is not to be continued longer than absolutely necessary for the destruction of the parasite. Sometimes it may be altogether contraindicated, or may be inconvenient, and then recourse may be had to styrax, tolu, petroleum, or iodide of potassium; but in most cases the preceding method will give satisfactory results.

Tinea Tonsurans—Chloasma.—The parasites in these maladies are curable by sulphur applications, but a compound ointment containing ammoniated mercury acts better than simple sulphur ointment (Ung. hydrarg. ammon., with an equal part of Ung. sulphuris, is a good formula).

Sycosis Mentagra ("*Barber's Itch*").—In this disease Hebra advises that the affected hairs should be pulled out, and then a paste containing sulphur, glycerin, and alcohol, in equal parts, should be rubbed over the diseased skin every night and morning; by this means a cure is rapidly effected, but it is rather severe treatment. It is especially adapted for the parasitic form, but is useful also in the more common one, because sulphur, as well as sulphides, lessens pus-formations.

Prurigo.—In chronic prurigo—especially when connected with phtheiriasis, but also in independent forms—an ointment containing sulphur with a preparation of tar is often of much service. Anderson recommends 6 dr. of pix liquida in 4 oz. of ordinary sulphur ointment (*Lancet*, ii., 1869). Sulphur vapor baths are useful. In ordinary pruritus I find a lotion of sulphurated potash very effective (*v.* p. 34).

Eczema—Psoriasis.—When eczema occurs as a complication of scabies, Hebra joins with the sulphur an equal quantity of tar and half the quantity of chalk; and there are some stages of idiopathic eczema when sulphur acts as a useful stimulant, viz., when the eruption is on the *decline*, but remains in obstinate chronic patches, especially about the legs. It acts best in lymphatic constitutions; but, as a rule, I prefer potash or tar applications to sulphur. I may say the same as to my own experience in chronic psoriasis, but compound sulphur ointments have been found useful in this malady; and part of the benefit following the use of caoutchouc bandages has been traced to the sulphur they contain

(Hebra). Dr. Wetzler states that ordinary psoriasis, when not much developed, can be cured by the Aix-la-Chapelle waters alone, if prolonged baths can be borne. In very extensive and obstinate cases, however, he adds iodide of potassium to the water, and prescribes in addition sulphurous vapor baths, tar-frictions, etc., and, it is stated, with the best results ("Practical Treatise," 1862, p. 66).

Acne.—With the exception of scabies, acne is the skin disease in which sulphur is most frequently used and gives the best results; the degree of stimulus or irritation supplied by it seems more appropriate than that of any other application, unless it be sometimes mercury. In the *simple acne* of young people, occurring in the sebaceous glands about the face and shoulders, accompanied by comedo and without much general congestion, a fairly strong preparation may be used, such as the sulphur ointment of the Pharmacopœia; or potash may be added to it (*Lancet*, ii., 1878), or a lotion containing 6 dr. of precipitated sulphur and 1 dr. of glycerin, with 6 oz. of rectified spirit (Anderson). When a moderate degree of irritation is present the proportions may be altered; thus, 1 dr. of sublimed sulphur may be rubbed up with a little alcohol, and then 2 dr. of the smoother variety may be added, with water to dilute sufficiently (Morris: *Lancet*, i., 1855); or a lotion that I commonly use with advantage is made with 2 to 4 dr. of precipitated sulphur, with the same quantity of spirit and glycerin, in 6 oz. of rose-water. Spirits of camphor or ether may be added, to relieve itching or heat, and special indications for internal treatment must be considered. Sometimes dusting with the pure, dry precipitated sulphur answers better than anything (Parsons: *British Medical Journal*, i., 1879). The local remedies should be lightly or firmly applied, according as they can be borne, left in contact all night, and washed off with mucilaginous decoctions or water in the morning.

For *acne rosacea*, one of the best applications is an ointment containing 2 dr. of the hypochloride of sulphur in the ounce of rumex ointment (Wilson), or a lotion of ½ oz. of sublimed sulphur in 4 oz. of elderflower water. The ointment of *iodide of sulphur*, which is still stronger, may be carefully used to chronic cases of any form of acne. A certain amount of temporary irritation must be expected from these remedies, and may require their occasional intermission and the use of sedatives; but some compound of sulphur, judiciously employed, will be found the most effective cure. The internal use of calcium sulphide should be conjoined with this treatment.

Burns—Scalds.—Dr. Myrtle, of Harrogate, has recommended sulphur ointment as a good application for burns and scalds (*Edinburgh Medical Journal*, 1862).

Granular Ophthalmia.—Wharton Jones has found advantage from the use of sulphur ointment as a stimulant, a small quantity being applied

between the lids at bedtime (*Medical Times*, i., 1859). There are, however, better applications than this.

Rheumatism.—The friction of rheumatic limbs with sulphur is as ancient at least as Pliny (lib. xxxv.), and attention was specially directed to it again some years ago by Dr. Fuller, Dr. O'Connor, and others (*Medical Times*, i., 1858). They found it useful also in sciatica and lumbago, adding to the frictions close and constant covering with flannel. Rénard found it very serviceable in rheumatism affecting tendinous parts, in his own person, after an acute attack; it produced some degree of heat and increase of perspiration when it acted well. It should certainly be tried in all obstinate forms of rheumatism, and especially that form which attacks the soles of the feet in those who are exposed to damp and cold.

It is in the different forms of chronic rheumatism and chronic skin disease that baths of sulphurous waters, as at Barèges and Aix-la-Chapelle, are found most valuable.

Therapeutical Action (Internal).—The therapeutical action of sulphur and the sulphides is somewat similar, but the former is commonly used in small doses to produce an "alterative," and in large doses a laxative effect, and the latter to modify some acute conditions, especially when they are connected with suppuration in various stages.

Skin Disease.—The *internal* use of sulphur for many skin diseases rests on an old tradition, but is not much adopted in modern practice. I have tried it extensively, and although the alkaline sulphurous waters are useful sometimes, and in *acne rosacea* the calcium sulphide, in ¼ to ½ gr. doses thrice daily, seems to help absorption of the tubercles and abate venous hyperæmia, yet, with these exceptions, I have not seen much advantage. Dr. Cane refers to sixteen cases of acne in which the last-named remedy was useful (*Lancet*, ii., 1878).

Scrofula—Swollen Lips, Glands, etc.—Scrofulous children are often disfigured by a chronic swelling of the upper lip and alæ nasi, which may be connected with a crack or fissure on the inner surface of the mucous membrane. Accompanying this condition, there often exists a tendency to dyspepsia and indolent swelling of the mesenteric, cervical, and other glands.

Although we cannot wholly cure the constitutional tendency in such cases by sulphide of calcium, yet I have seen their general condition greatly improved by small doses (¼ gr.) given night and morning for a few weeks; the fissure has healed and the lip-swelling subsided, and the glands have grown less.

In cases where pus has actually formed in some of the glands, the effects of this remedy may readily be traced in the subsidence and disappearance of some of the swellings, while others progress quickly, maturate and discharge, and others that have been open and discharging unhealthily for some time take on healthy action, and ultimately contract

and heal. For permanent good results this treatment should be followed up by cod-liver oil and generous diet, and, if possible, change to the seaside. As a rule, frequent doses of the sulphide are not desirable, as they are apt to derange the stomach and cause troublesome eructation of sulphuretted hydrogen.

Scrofulous Ophthalmia, etc.—In this affection I can recommend sulphide of calcium, and especially when ulceration of the cornea is present; it also acts well in scrofulous otorrhœa, and indeed in almost all purulent discharges occurring in children, especially when becoming fetid and obstinate in character.

Suppuration.—Calcium sulphide exerts a marked influence on the formation of pus. If given early, it controls the inflammatory process, either aborting it so that it does not go on to suppuration, or, if this take place, controlling and limiting its extent, promoting a more healthy formation, quicker evacuation, and more rapid subsequent healing.

In the treatment of simple *abscess* I have frequently used it with much advantage; in tonsillar abscess (quinsy) it is particularly valuable, and may save recourse to incision; and in mammary abscess, if the time for belladonna or antimony is past, the sulphide is quite the best remedy. It has seemed to me to check the spread of the inflammation, and to help quickly to evacuate matter, and so shorten the tedious course common in this malady. Should hardness and pain continue after an opening has formed, and should the discharge come away incompletely, the remedy must still be continued, and is likely to exert a favorable influence.

In *bubo*, especially if indolent, and with scanty, unhealthy pus-formation, the sulphide will often determine a more healthy action; $\frac{1}{4}$ to $\frac{1}{2}$ gr. in pill every three or four hours is a suitable dose.

In ordinary *boils*, and in *carbuncles* also, a compress moistened with sulphide of calcium lotion—(4 gr. to the pint of water)—should be applied. When eruptions of boils recur at intervals, I commonly advise a course of the precipitated sulphur—5 to 10 gr. night and morning—for several weeks during the intervals, but, at the time of actual maturation, recommend the sulphide as acting more quickly. Even in *pneumonia*, in those exceptional cases when the exudation in later stages degenerates into pus, I have seen benefit from the same remedy; it has equally seemed to assist evacuation of matter already formed, and to check the tendency to its fresh formation.

Syphilis.—In most of the later manifestations of this disorder, sulphurous waters have a good reputation, but, in my opinion, without sufficient reason. At Aix-la-Chapelle, for instance, the treatment is conducted mainly by mercurial inunction, and the sulphur-waters used locally and internally, can only be considered adjuvants to this more powerful remedy. I think they serve mainly to cleanse and stimulate the skin, to regulate the action of the bowels and viscera, and to counteract any injurious ef-

fects that might arise from the mercury (*v.* p. 170). They have, perhaps, a further use for diagnostic purposes, since it is said that obscure symptoms really due to old or latent syphilis manifest themselves more fully under a course of the waters, and thus give the necessary indications for treatment by iodides or mercury. Dr. Wetzler gives several instances of this (op. cit.), and I have no doubt of its possibility.

I must say also that I have seen advantage from the use of sulphide of calcium in *syphilitic laryngitis*, notably when mercury had been previously taken to saturation.

Diphtheria.—During certain stages of this malady, preparations of aconite, iron, iodine, bromine, etc., are indicated, as described under those medicines; but at the time when pus is commencing to form, and the false membrane is becoming somewhat loosened from the mucous surface, the sulphide of calcium is often useful, for it exerts the action already referred to, of assisting to healthy completion and at the same time limiting the extent of the suppurative process. We know that this formation of pus-cells occurs as part of the diphtheritic inflammation before the return of healthy conditions, and, as remarked by Mackenzie (who does not, however, mention this remedy), "when it is found impossible to check the formation of lymph, it is rational treatment to convert, as far as we can, the inflammatory into a suppurative process" ("On Diphtheria," 1879). If commenced early in this stage, in doses of $\frac{1}{10}$ to $\frac{1}{4}$ gr. every one or two hours, it produces the best effects; but it is useful also even if begun after pus-formation is fully developed, and I believe it has some influence in lessening blood-poisoning. The value of steam-inhalation in helping on the natural changes of diphtheria and the formation of mucopus and loosening of the membranes has been often proved (P. James, Oertel), and is now well known. I find it still more efficacious if the sulphide of calcium be added to the boiling water in the proportion of about 4 gr. to the pint, so that a certain amount of sulphurous vapor is locally applied.

The local insufflation of finely powdered sulphur has been credited with arresting the development of diphtheritic exudation (*Practitioner*, November, 1868, vi.), but has disappointed expectation. Oertel concludes, after much experience, that it acts only as a "scouring powder," wearing off the membranes by friction; it has no influence at the onset of the malady, but has seemed to answer only when purulent infiltration and fibrinous exudation have already ceased. It has an antizymotic, but no other specific power, and is liable to cause irritation (*British Medical Journal*, January 11, 1879).

Mr. Erskine Stuart has, however, written still more recently in favor of local applications of precipitated sulphur. According to his latest experience, "it is best applied, after being rubbed up with a little water, on a swab to the affected part; it is free from grittiness, it sticks better, and

hence exerts its action for a longer time, and is applied more safely in this manner than by insufflation." He states "that every case treated with sulphur made a rapid recovery" (*Practitioner*, October, 1879), but the number apparently is not more than six, and he unduly depreciates other remedies.

In *Laryngo-tracheal Diphtheria* (*Croup*), when we cannot always see the false membrane, I find the sulphide of calcium treatment indicated if wheezing, rattling sounds accompany the breathing, *i.e.*, when the membrane begins to be loosened, rather than in the first stage, when the breath-sounds are of dry and sawing character.

Chronic Sore Throat.—Dr. Guéneau de Mussy has specially pointed out the value of sulphur waters in "glandulous angina," which, under ordinary treatment, is an obstinate malady. The waters of Eaux Bonnes are of remarkable efficacy in such cases (*v.* Mineral Waters); the sulphurous acid spray is also useful if not too irritating.

Scarlet Fever.—Mr. Pigeon believes that in sulphur he has found the true remedy for this fever, and he certainly applies it very thoroughly, and appears to have had good success. He anoints the patient twice daily with sulphur ointment, gives 5 gr. of sulphur by the mouth twice daily, and fumigates frequently with sulphur vapor (*Lancet*, ii., 1876).

Variola.—Sulphide of calcium, I believe, often moderates excessive suppuration in this malady.

Asthma—Chronic Bronchitis.—In cases with much cough and profuse secretion, sulphur will often relieve, lessening and modifying the expectoration. I have seen this accomplished in many instances. The old physicians described it as "balsamum pectoris," and it still forms part of some quack "nostrums." Dr. Graves records his experience in its favor. Binz suggests that sulphuretted hydrogen, being excreted by the bronchial mucous membrane, may partially narcotize the terminals of irritated bronchial nerves, and advocates for the continued use of small doses of sulphur in asthma are not wanting (Duclos: *Bulletin*, 1861). I have seen cases marked by loud wheezing, profuse but difficult expectoration, troublesome palpitation, and nocturnal spasms of severe dyspnœa, improve quickly with 5 to 10 gr. of sulphur taken thrice daily. The sulphur springs of Weilbach are celebrated for relieving cases of chronic bronchitis, especially when complicated with hæmorrhoids.

Phthisis.—Sulphur was well known to the ancients as a remedy in consumption, and Galen ordered to phthisical patients inhalation of the vapor from the crater of Etna. It is not much used internally in modern practice, but for chronic phthisis the springs at Weilbach have a favorable reputation.

Sutro finds sulphur of good service in some cases of phthisis, and the presence of hæmorrhoids is one indication for it; he suggests that it combines with the iron of effete blood-corpuscles, quickens the elimination of

this and other residua, and thus relieves the portal system and indirectly the lungs (*Medical Times*, i., 1862, p. 362), and I quite agree with those observers who have noted, in this disease, much advantage from the use of sulphur both internally and by inhalation. Dr. Dewar relates instances where sulphurous acid and steam acted unexpectedly well on phthisical subjects exposed to them (*Medical Times*, i., 1867). A spray containing sulphurous acid facilitates expectoration, and also disinfects and lessens purulent secretion, and so far relieves certain symptoms, but has no specific power over the disease.

Chronic Rheumatism.—Sulphur frictions for rheumatism have been already mentioned, and the drug was formerly considered a good internal remedy for chronic muscular and articular pain, and no doubt it is often of real value when given in doses of from 5 to 20 gr. twice daily for some time—I think the smaller doses give the better results. Remedies calculated to produce diaphoresis, such as vapor-baths, should be generally combined with its use. In acute articular rheumatism it has little or no power.

Paralysis.—In chronic and asthenic cases of impaired motor power, the use of sulphur internally and externally deserves a fair trial. Dr. Graves was accustomed to depend upon it after a course of strychnia. Wetzler has recorded four cases of progressive muscular palsy benefited by warm sulphur-baths and the administration of the water at Aix-la-Chapelle (*British and Foreign Review*, ii., 1856, p. 457), and in his treatise (1862) has added several other cases. Althaus found these remedies useful in locomotor ataxy (*Lancet*, ii., 1865). I have also seen some advantage from them in the latter condition.

Mercurial Tremor—Mercurialism.—In cases of palsy and tremor connected with the action of mercury, sulphur is useful (Lettsom) and deserves trial; it is said also to neutralize acute mercurialism accompanied with salivation, etc., and may be given in 5 to 10 gr. doses at the same time as chlorate of potash. On the other hand, in patients who have taken mercury at some previous period, sulphur, like iodides and other powerful alterants, has sometimes determined a fresh salivation.

Lead-Colic—Lead-Palsy.—In these conditions sulphur has been found available, though iodide of potassium is now proved to be better. In an epidemic of lead-poisoning at Havre, M. Marguerette found sulphur give much relief; it required to be exhibited at first in very large doses (50 grammes in the first day), being afterward gradually diminished as the symptoms improved (*Bulletin*, October, 1867).

Hepatic Disease.—Chronic enlargement of the liver, with obstruction to the portal circulation, accompanied as it usually is by hæmorrhoids, is often much benefited by a course of sulphur, or of calcium sulphide, or potassium sulphide.

Constipation—Hæmorrhoids.—The mild action of sulphur on the mu-

cous membrane, or muscular coat of the intestine, renders it a useful aperient for children and delicate persons, especially if there be congestion about the rectum or pelvic viscera. In cases of hæmorrhoids it is one of the best laxatives, and if not powerful enough may be combined with tartarated potash, or with confection of senna. A "compound liquorice powder," in which sulphur is the main ingredient, has recently been introduced into the British Pharmacopœia, but the Prussian formula, which includes also finely powdered senna, is superior. In the treatment of piles, sulphur need not be given in quantity sufficient to produce a laxative effect, unless this is otherwise required, for it can relieve by virtue of a stimulant and tonic action on the venous and capillary circulation, especially of the rectum and pelvic viscera, without any direct aperient action. The ordinary dose should be 5 to 10 gr. morning and night. Weak sulphur ointments locally applied increase the good result. The remedy may also be used in the form of vapor, and if the fumes from burning sulphur can, by means of apparatus, be applied directly, they often relieve congested, painful, bleeding piles; this is a popular domestic "cure" in some parts of the country (Pairman). Dr. Thorowgood attributes to sulphur a special value in torpor of the colon, which often causes or complicates dyspepsia; he recommends 10 to 20 gr. to be taken in the early morning with nux vomica; the lozenges of Holsverck contain the same ingredients (*Lancet*, i., 1869; *Medical Times*, i., 1858, p. 457).

Diarrhœa — Dysentery — Cholera.— Dr. Blacklock, of the Madras army, and Dr. Graves quote an extensive experience in favor of the efficacy of sulphur in these maladies; the latter observer combines it with soda and spirits of lavender, and in severe cases with opium ("On Cholera," 1865). Mr. Prosser also finds drachm doses given with mucilage to be "one of the best remedies in epidemic diarrhœa and cholera," (*Lancet*, ii., 1866, p. 483). This is not a general experience, nor is it mine, although I have found sulphur in 2 or 3 gr. doses useful in the fetid, watery diarrhœa of scrofulous children, and in some cases of chronic dysenteric diarrhœa with tenesmus.

Disorders of Menstruation.—When the menses are delayed in weakly and phlegmatic persons, sulphur used as an habitual laxative has some influence in bringing on the flow; on the other hand, it has been recommended for relieving uterine congestion and its consequences at the climacteric period (Tilt).

Ascaris Vermicularis.—Precipitated sulphur is often a simple and efficient remedy for these parasites; 5 to 10 or 15 gr. should be given daily, morning and night, for some weeks.

Preparations and Doses.—*Pure precipitated sulphur* is more finely divided, and is thought to be more active, than the sublimed form; the dose of either is, however, the same, 5 to 10 gr. as a stimulant, 20 to 60 gr. as a laxative; it is well given in milk, honey, or treacle. *Confectio*

(made with *sublimed sulphur*): dose, 60 to 120 gr. *Unguentum* contains 1 part to 4 of benzoated lard. A milder and often more useful form of ointment is made with half the amount of sulphur and ½ dr. of carbonate of potash to the ounce; essence of lemon conceals the odor (Squire). *Solutio calcis c. sulphure* may be prepared by boiling together 1 oz. of quick-lime and 5 of sublimed sulphur in 1 pint of water for half an hour; filter, and make up, if necessary, to half a pint; a similar solution is now commonly sold by wholesale chemists. *Lotio potassæ sulphuratæ* may be prepared with 1 dr. to half a pint of water for use in irritable skin eruptions. *Balneum potassæ sulphuratæ:* ½ lb. to 30 gallons of water, in porcelain or wooden vessel. *Balneum sulphuris compositum* (Startin): precipitated sulphur, 2 oz.; hyposulphite of soda, 1 oz.; dilute sulphuric acid, ½ fl. oz.; water, 1 pint: to be added to 30 gallons of water. *A sulphur vapor bath* may be prepared by evaporating ½ oz. to 2 oz. of the solution of lime and sulphur by means of a spirit-lamp placed under a suitable arrangement of chair, coverings, etc.; the face should be protected from the vapor (*Medical Times*, i., 1870, p. 308).

[Preparation, U. S. P.—*Unguentum Sulphuris:* sublimed sulphur, 1 troyounce; lard, 2 troyounces.]

Adulterations.—The precipitated sulphur commonly sold, especially before the passing of the Adulteration Act, contained a large proportion of sulphate of lime; this was due to the employment of sulphuric acid instead of the hydrochloric acid ordered in the Pharmacopœia; but, as some excuse, it may be mentioned that a former London Pharmacopœia contained a preparation made with sulphuric acid, and known as "milk of sulphur." This name has now been transferred as a synonym to the modern "precipitated sulphur," and hence has arisen much confusion and even litigation. Druggists have been prosecuted for supplying the lime compound when asked for "milk of sulphur," and although convicted by some magistrates of offences against the Act, the convictions have mostly been quashed on appeal to a higher court, on the ground that "milk of sulphur" is known by trade custom to be a distinct thing from the pure precipitated form. It is desirable that this should be particularly understood (*British Medical Journal*, i., 1877; *Lancet*, i., 1876, p. 936). As a rule, a pure preparation may be obtained by asking for that of the British Pharmacopœia. An adulterated specimen is whiter, with only slight yellowish tinge, and when pressed looks silky and glistening; under the microscope, crystals may be seen in thin tables or elongated prisms, and on exposure to a red heat, lime is left as a white ash (*Medical Times*, i., 1853). Washed Sicilian sulphur is nearly always pure, but that prepared from pyrites often contains arsenic.

PHOSPHORUS, P,=31.

This non-metallic element was obtained in the seventeenth century from the urinary phosphates, by German chemists, and by Dr. Boyle in this country. London was, for some time, the principal place of its manufacture, so that it became known as "phosphorus anglicanus." It occurs, variously combined, in certain especially fertile soils, in the seeds of vegetables, and in the nerve-tissue and bone of animals (particularly when young), as well as in the blood and the urine.

PREPARATION.—It is now procured from bone-ash (os ustum) by digesting it in sulphuric acid, and then distilling with charcoal.

The contained phosphate of lime is partially changed into superphosphate and metaphosphate: phosphorus distils over, and, by a further process of purifying, is obtained as a colorless, oily liquid, which solidifies in cakes, or in rounded hollow pencils, according to the shape of the glass moulds employed. The last part of the process may be represented thus: $3Ca(PO_3)_2+10C=4P+Ca_3(PO_4)_2+10Co$.

CHARACTERS.—The cakes or pencils are colorless, waxy, and translucent when fresh, but on exposure become coated with an opaque layer of crystals, which may be white, yellowish, or sometimes red from the formation of an allotropic variety of phosphorus. Phosphorus inflames so easily that it needs to be kept under cold water, in which it is practically insoluble; in ether, turpentine, and oils it is soluble to a great extent; in rectified spirit it is but slightly so (1 part in 320); in chloroform, 1 per cent.; but in bisulphide of carbon it is wholly soluble. ("Fenian fire" is the term given to a very inflammable solution in this liquid, containing 70 per cent.) Naunyn states that phosphorus is very slightly soluble in water at 96° to 104° F.; it is more soluble in organic fluids. The element is soft and flexible at ordinary temperatures, melts at 110°, and takes fire at a little over that point; it is luminous in the dark, and, when exposed to air, gives off white vapors of phosphorous acid, exhaling an odor *sui generis*, which has been compared to that of garlic.

On exposure to sunlight or to heat in closed vessels, it is converted into red or "amorphous" phosphorus—a brittle powder which is not acted on by the air, and is insoluble; when volatilized, this reverts to the ordinary form.

Amorphous phosphorus has been, by some observers, credited with physiological activity. Thus, Bednar used it for a long period in small doses, and observed symptoms of excitation, trembling, and clonic convulsions; but as much as 1 oz. has been given to dogs without perceptible effect. Thompson, in twelve carefully observed cases, found its action *nil*, and plausibly attributes its supposed powers to a slight amount of contained ordinary phosphorus (*Pharmaceutical Journal*, July, 1875).

I believe it to be practically inert, and the following observations will refer only to the ordinary form.

Zinci Phosphidum — Phosphide of Zinc, PZn_3 (not officinal). A grayish, friable substance, having a lustrous, crystalline fracture, stable at ordinary temperatures, readily decomposed by weak acids, almost tasteless, but possessing active properties like those of phosphorus.

Absorption and Elimination.—Phosphorus taken by the mouth, and especially when finely divided or dissolved, is absorbed into the blood under the influence of alkaline, albuminoid, or oleaginous materials with which it meets in the stomach and intestine; the amount and the rapidity of its absorption are proportionate to the amount of such materials, and especially of fats, which are its *best* solvents. The exact condition in which it circulates is still a subject for discussion; according to varying circumstances some portion may pass into the blood *unaltered* (Orfila, etc.), another oxidized, as hypophosphorous, phosphorous, or phosphoric acid (Frerichs, Munk and Leyden, etc.), and a third portion as phosphuretted hydrogen (Lecorché: *Archives de Physiologie*, 1–2). It has been found in each of these forms in certain cases of poisoning, though in other cases none at all has been detected.

Portions of unabsorbed phosphorus pass sometimes with the fæces, rendering them phosphorescent, and the urine has presented a similar appearance: the element has also been found in a free state in the liver, ten hours after death (Dybkowsky); it is eliminated by it, and by the other glandular organs, by the skin, and by the lungs.

Physiological Action (External).—When applied in substance, phosphorus has been known to inflame on the skin, and, indeed, has been used as a moxa; it is liable to cause very troublesome sores and even gangrene, and the same results may follow its use in ointment. In certain experiments on *dogs*, however, when pieces of the element were placed in the cellular tissue they remained unaltered as to size and translucency, and no inflammation was excited, yet the animals are said to have died in a few weeks from phosphorus-poisoning; while, on the other hand, rabbits and some other animals treated in the same way did not show either local or general symptoms. Trasbot records a curious circumstance: a dog swallowed a stick of phosphorus, and no symptoms of local irritation appeared, and afterward it was found in an abscess as an ordinary foreign body might have been. It is not easy to draw definite conclusions from such experiments, other than that pure phosphorus does not necessarily act as a local irritant (Ranvier: *Gazette Médicale*, 1867; *Archives Générales*, 1868). Phosphorus vapor causes irritation, catarrh, and even inflammation of mucous membranes with which it comes in contact, especially the conjunctival and respiratory membranes; it has also a special effect in causing inflammation of the *periosteum* and *bone*, with necrosis of exposed parts, such as the maxilla and teeth. It is only when

the phosphorus vapor *directly* reaches the periosteum or some raw vascular surface in immediate connection with the nutrition of bone, and when its application is prolonged under particular circumstances of temperature, and probably of oxidation, that its injurious effects are witnessed. Thus it is, when there are carious teeth in the jaw, and the fumes can act directly on the exposed dental pulp, that necrosis occurs, and it is noteworthy that not until eleven years after the opening of the match factory in Vienna was the first case of this kind seen, and only those engaged in "dipping and drying" the matches were affected. The disease is more common in the lower jaw, but not rare in the upper, and it has also attacked the palate and frontal bones. The general health of the workers previous to the necrosis or buccal inflammation is, with the exception of pulmonary catarrh, remarkably good.

Physiological Action (Internal).—*Digestive System.*—After taking, in ethereal tincture, $\frac{1}{50}$ gr. each morning for ten days, and then $\frac{1}{100}$ gr. for nearly four weeks, I experienced increased thirst and dryness of mouth, with coated tongue, flatulent distention and eructation, and uneasy feeling in the region of the gall-bladder, without nausea or vomiting; the motions were dark, but healthy, the urine natural. There was slight headache and sense of fulness along the vertex and over the left temple, with increased restlessness and sleeplessness. On discontinuing the medicine, these symptoms disappeared in about three days, and on resuming it at the end of a month I felt them return in about ten days' time. Other persons may take the quantity just mentioned without so much inconvenience, but larger doses ($\frac{1}{30}$ to $\frac{1}{15}$ gr. and upwards) are very liable to disorder the stomach, causing nausea and a sense of warmth or irritation. The appetite may be at first increased, but in many patients dyspepsia quickly occurs, and nausea, flatulence, colic, or diarrhœa hinders the employment of at least the ordinary preparations of phosphorus. A silvery white condition of the tongue may be caused, and the gums may become inflamed. *Zinc phosphide* in any quantity above $\frac{1}{4}$ gr. readily induces vomiting.

Professor Gubler, examining the effects of this phosphide upon artificial digestion, found that the phosphuretted hydrogen which was developed arrested the process, and he concluded that the same thing occurred with other preparations of phosphorus taken by the stomach; while Dr. A. Thompson attributes gastric irritation to the formation of hypophosphorous acid, and states that he has only seen these symptoms occur after the use of mixtures prepared with a *vegetable* oil.

Whatever the precise explanation may be, the limit of medicinal and the commencement of toxic doses is marked by more evident irritation of the digestive organs—the mouth becomes tender and sore, the nausea is accompanied with retching, vomiting, and diarrhœa; tenderness and enlargement of the liver may be detected, and there is an icteric tint of

skin and conjunctivæ. In the irritant form of phosphorus-poisoning (to be described separately), these symptoms become very severe.

Cutaneous System—Mucous Membrane.—A good deal of irritation with hyperæsthesia may be determined in the skin and the conjunctivæ, as well as in the buccal membrane, by the use of phosphorus. It is not easy to say whether this is caused by the elimination of the drug, or by the presence of biliary compounds from altered liver-function, or from impaired blood-condition; the icteric tint has been already mentioned. In cases of poisoning, erythematous and hemorrhagic patches occur in the skin, and increased perspiration has been traced to the medicinal use of the drug.

Genito-urinary System.—There is but little evidence of any stimulus to the generative function or organs exerted by phosphorus given to healthy subjects, whatever may be its power in certain forms of disease. The stimulation that has been noted in some cases, both of men and animals, was not *special*, but merely a part of the *general* stimulus to the whole nervous system. Leroy, indeed, and some other French authors, have reported some temporary genital stimulation from large doses, and, in a few cases of poisoning, irritation and excitement of the genitalia have been recorded, but they are to be explained as above. Thompson gave to two healthy adults 1 to 1½ gr. of zinc phosphide daily for eight or nine days, and to another ⅛ to ¼ gr. of free phosphorus until symptoms of incipient poisoning arose, but without any trace of aphrodisiac effect. Dr. Eames has reported similar negative results from observations with phosphuretted oil, and Mr. Bradley's experience is to the same effect.

With special reference to this point, I have myself carefully experimented upon twenty healthy men. Ten of them took $\frac{1}{10}$ gr. daily for a fortnight; five took ⅛ gr. each day for a similar period; and the other five took ½ gr. every third day for five successive doses. Toxic symptoms occurred in some of the subjects, but, except possibly in one of the last set, no sign or feeling of increased sexual excitement was observed. I have, however, seen men from forty to sixty years of age, apparently in good health, but suffering from complete loss of generative power (in consequence either of previous sexual abuse, or of overtaxed brain and nervous system), in whom very small doses—$\frac{1}{200}$ gr. thrice daily—caused weak erections and involuntary emissions, but mental depression was developed to such an extent as to compel the suspension of the drug: this implies a state of irritation, but certainly not one of increased tone or strength.

With regard to its influence upon the *uterus*, we have evidence that long-suppressed menstruation may reappear under its continued use in small doses, but this may reasonably be connected with improvement in the blood-condition rather than with specific stimulation; in cases of poisoning, however, uterine hemorrhage and abortion occur (*v.* p. 41).

The urine under the influence of phosphorus becomes high-colored and loaded, sometimes phosphorescent, and with a smell of violets, or of sulphur.

Husemann reports the nitrogenous constituents increased in amount, and more recently, in dogs poisoned by phosphorus, Bauer found the excretion of urea notably increased—20 to 90 per cent. above normal (*Zeitschrift für Biologie*, Bd. xiv., Hft. 4, 1878); the phosphates are unaltered in quantity (Derlon). Leucin, tyrosin, and paralactic acid have been found in cases of poisoning.

Osseous System.—Wegner has furnished definite proof that phosphorus stimulates the growth of true bone, for, after giving minute doses continuously to animals, he found the epiphyseal cartilages ossify more quickly and more completely than usual, and the cancellous and compact bone become more dense, even to the extent of obliterating the medullary canal (Virchow's *Archiv*, June 22, 1872). Exostoses commonly form in cattle feeding near the bone-works at Swansea, and have been plausibly traced to phosphorus fumes in the surrounding atmosphere (Stanley on Bones: *Medical Times*, 1854), and although we find clinically that inflammation and necrosis follow the direct local irritation of strong phosphorus vapor, yet even in such cases exostoses commonly form in another part of the same bone.

Nervous System.—The fact just recorded of phosphorus stimulating the growth of bone—a tissue of which it forms a component part—has led to the inference that it can stimulate the nutrition of nerve-tissue, of which also it forms a normal constituent; but the evidence on this subject is rather clinical than experimental. Gubler describes the effect of $\frac{1}{30}$ to $\frac{1}{15}$ gr. to be a "general sense of stimulation more complete than that caused by coffee, more active than that produced by opium." A. Thompson speaks of it as producing "exhilaration and increased capacity for exertion, both mental and physical, and an effect like that of alcohol without the subsequent depression." He states also that if $\frac{1}{2}$ to 1 gr. be taken in the course of twenty-four hours, the feelings described are more sustained, and transient giddiness or quasi-intoxication occurs. There seems to me some exaggeration in these accounts, but it is within my own experience that a general tonic effect may be obtained from these and smaller quantities of the drug. In cases where poisonous symptoms are developed, marked excitement, tremor, and spasmodic muscular twitching occur, and, in severe cases, cramp or partial paralysis, delirium, convulsion, collapse, or coma.

Circulatory System.—In accordance with the slight general excitation already described, the pulse and temperature are slightly raised about an hour after taking doses of $\frac{1}{30}$ gr.; and after such doses, given daily for some weeks, the circulation has been found more equable and more steady than before (Dr. Ford on fifteen patients: *American Journal*

of Insanity, January, 1874). Thompson has noted dilatation of the skin-capillaries. In toxic cases the pulse rises to 120 or more per minute, and the temperature to 102° to 103° F., though this condition is only temporary.

Dr. Gowers has proved that, under the influence of small, continued doses, the proportion of red blood-corpuscles is increased (*British Medical Journal*, i., 1878), at least in lymphoma, and this interesting observation may throw light on the tonic power of the drug.

Toxic Action.—The poisonous symptoms produced are essentially of irritant and destructive character, but vary in degree, and are often obscure and insidious—probably in proportion to the varying amount absorbed, or the chemical changes the drug undergoes under different circumstances. Lecorché makes three forms of "acute phosphorismus": 1, that produced by phosphuretted hydrogen; 2, that by phosphoric acid; 3, a mixed form; but the clinical varieties described by Trousseau, or better by Dr. Guy, are of more practical importance—he names them as 1, the irritant; 2, the nervous; and 3, the hemorrhagic form—and a brief notice of them comes within the scope of our subject, because it will help to fix in the mind of the reader the characters of the full physiological action of the drug.

1. *The irritant form* is the most common: it is induced (on the Continent, not infrequently) by swallowing match-heads, or a certain rat-poison paste. A foul taste and smell, like garlic or sulphur, are first perceived, then heat and swelling of the tongue and fauces, pain and distension of the stomach, bilious and mucous vomiting and purging, with colic and abdominal tenderness. The ejecta occasionally contain blood, and may be phosphorescent, and the fæces contain small masses of crystals of the fatty acids, and later in the attack become clay-colored. The pulse rises to 120 or higher, and the temperature to 102° or 103° F.; but this pyrexia passes away as the gastro-intestinal symptoms become very severe, and is succeeded by an opposite condition (Gubler).

In the early stages there is pronounced nerve-excitement, with hyperæsthesia, agitation, talkative delirium, and delusion, which is sometimes of erotic character, though priapism is rare. Muscular twitchings and cramps, and even general convulsions occur, but later on follow prostration, fainting, and collapse, loss of muscular sense, and of sensation, retention of urine, and partial paralysis, affecting mostly the extensor muscles.

2. *In the nervous form* these latter symptoms become much more marked, but there is little pyrexia; erythematous spots occur in the skin, which is dry and yellow, and later becomes cold; dilatation of pupil and strabismus are described, and the fatal termination comes on with somnolence and coma.

3. *The hemorrhagic form* is less quickly fatal than the others. In it

the ejecta are almost wholly sanguineous; bleeding occurs in and from the skin and mucous membranes, and many parts of the body. It is due partly to the altered blood-state, and partly to general softening of the tissues, including fatty degeneration of vessels (Lebert). In women there is uterine hemorrhage, miscarriage, or abortion—but these may be due to the irritant effects on the intestinal canal.

In all cases of phosphorus-poisoning, about the third or fourth day pain is felt over the liver, and is followed shortly afterward by jaundice, headache, and sleeplessness; the urine is found to contain bile, and generally albumen, leucin, tyrosin, and paralactic acid. The presence of bile is an argument that the jaundice depends not on suppression, but on occlusion of the biliary passages, which is probably catarrhal in character. In exceptional cases (in which, probably, only a small amount of the poison has been absorbed) there has been neither gastro-enteritis, nerve-excitement, nor quick pulse, but the prominent symptoms have been jaundice and hepatic congestion (*British and Foreign Review*, April, 1863). The time that elapses from the taking of the phosphorus to the appearance of symptoms varies from a few minutes to two days. Death, when it occurs, is usually from asthenia, but the course of the illness is not always steadily progressive: sometimes the severe symptoms subside for a few hours or days, and death takes place *suddenly*, from failure of the cardiac muscle (Habershon: *Medico-Chirurgical Transactions*, v., 50). A fatal dose may be stated as about 1 to 2 gr. for adults, but much less for children, in whom vomiting and convulsions are usually the prominent symptoms.

Tolerance.—The system may become habituated to the use of phosphorus to some extent, and a gradual increase of dose may be borne up to an amount which would not at first be tolerated. In using it for neuralgia, Thompson has found that cases not relieved by a gradually increased dose have yielded to a similar dose, given *at once* after allowing an interval to elapse. Any "cumulative action," so called, may be explained by the mechanical accumulation of the drug in the stomach or intestines.

Pathological Changes induced by Phosphorus.—Ecchymoses and gangrenous spots have been found in the intestinal tract, together with swelling and softening of the mucous membrane and mesenteric glands; rarely perforation. The viscera are hyperæmic, and œdema and hemorrhagic infiltration affect the skin, serous membranes, and other tissues, especially the mediastinum; hemorrhage has also occurred between the spinal membranes, thus accounting for a paralysis. The blood itself is black and viscid, and in many cases, even during life, the corpuscles are destroyed and the hæmoglobin altered, so that it will not show the usual spectrum (Lecorché, Voit, etc.); in others the corpuscles have been found normal after death, and the blood-crystals (of hæmoglobin and hæmato-

crystalline) found unchanged (Lebert, Gubler); but in all cases the blood and the solid organs contain an increased proportion of waste products, such as urea, creatin, leucin, tyrosin, etc., and fatty degeneration affects every tissue. The muscles, including the cardiac muscle, are discolored, soft, and fatty, the capillary walls are degenerated in a similar manner, the gastric glands and renal tubules are choked with fatty epithelium, and the liver especially is enlarged, yellow in color, and its cells filled with fat-globules; in protracted cases, cell-atrophy occurs.

The condition described resembles closely that found in an idiopathic malady, "acute yellow atrophy" of the liver, and the question of diagnosis has been raised in medico-legal cases (*Annales d'Hygiène*, January, 1869). An illustration is recorded by Surgeon-Major Martin, in a man admitted to Netley Hospital without any history of poison, and whose case was diagnosed as acute yellow atrophy; it was only after death that the real fact of phosphorus-poisoning was disclosed by examination (*British Medical Journal*, i., 1878).

Theory of Action.—The direct irritant effects on the intestinal canal depend rather upon the oxygen—or hydrogen—compounds formed, than upon phosphorus itself, and the pain, vomiting, prostration, etc., follow from the local irritation produced, just as with other corrosive poisons.

To explain the other constitutional symptoms, and the subsequent arrest of nutrition and fatty degeneration, several modern writers have argued that the strong affinity of phosphorus for oxygen leads it to abstract that vital gas from the blood, and so induce a condition of *asphyxia* (Eulenburg Lecorché); but, as oxygen would be continually renewed by inspiration, and the amount that can be absorbed by the metalloid is only limited, I cannot see that such serious consequences would result; neither would asphyxia produce preliminary excitement nor subsequent waste, nor is the blood of poisoned animals *always* found black; it is sometimes red, a condition incompatible with asphyxia (Vigier: *Bulletin*, 1868). Others have argued that phosphorus indeed removes oxygen from the blood and the tissues, but with the main result of forming phosphorous and phosphoric acids, which act as *local* corrosive agents, and which, after absorption, destroy blood-corpuscles. The stomach contains some free oxygen, especially after food (Chevreul), and it has been suggested that, when the drug is taken under circumstances which favor its retention in the stomach and its oxidation there, then gastro-intestinal troubles are the most marked (*irritant* form of poisoning). That phosphoric acid is formed in the system seems proved by its excretion from the lungs; and further, it is pointed out that this acid, when injected into the veins, will destroy the corpuscles, and will lead to fatty degeneration (Personne); and although it will not act thus when given by the mouth, yet it may do so when directly generated within the system by the oxidation of free phosphorus. While allowing this to some extent, I cannot believe it

possible that a sufficient amount to account for such results could be formed in this manner. Again, oxygen has proved an antidote to phosphorus-poisoning (Crocq), and turpentine acts as an antidote by a process of oxidation, while free ventilation is the best means of preventing necrosis of the maxilla, etc., in phosphorus factories (Savory, Sieveking), so that it seems at least unlikely that *oxidation* of phosphorus is the cause of its ill-effects.

In explaining the action of the drug I incline to accept the theory of Gubler, who suggests that it acts chiefly by the strong *ozonizing* power which we know burning phosphorus to possess. Although through this combustion a minimum quantity of oxygen gets lost for the respiration, the remainder would shortly acquire, from its admixture with the ozonized portion, so great an increase in combustion power as to be very likely to induce general stimulation of the system. But increased activity is accompanied by an increased waste, particularly of the blood-cells; anæmia follows this irregular activity, and fatty degeneration of the tissues and impairment in the function of the different organs take place. On the other hand, amorphous phosphorus, which has no ozonizing power, would fail to produce any such symptoms, as is really the case; but more accurate analyses of the secretions are required in order to support this hypothesis. The excretion of carbonic acid is said to be lessened (Rabuteau) —we should not expect this unless in advanced stages; as already stated, nitrogenous excretions are increased in amount, while the urinary phosphates remain about normal.

I have still to refer to the effects of *Phosphuretted Hydrogen*, which would readily be formed from water and phosphorus, or from any phosphides, or from the very unstable hypophosphorous acid. We have seen that this gas interferes with the digestive process, and we know that, if it be passed into defibrinated blood, it turns it black and destroys its hæmoglobin (Dybkowsky); also that it possesses, equally with phosphoric acid, and other acids and substances which act destructively on the blood, the power of inducing fatty degeneration from impaired nutrition (Bence Jones and others: *Medical Times*, ii., 1865, p. 593). The formation of phosphuretted hydrogen in the system would equally well explain the production of the principal toxic effects of free phosphorus, and I incline to attribute them largely to it. Lecorché states that this compound has been found in the tissues in fatal cases, and he connects its presence specially with the second or neurotic form of poisoning, in which the course is rapid and nerve-symptoms are prominent.

Fatty degeneration was found by Munk and Leyden in the tissues of frogs and rabbits within two or three days after giving phosphorus (*Medical Times*, ii., 1865, p. 593), and since these researches its occurrence in phosphorus-poisoning has been amply demonstrated, especially by German observers (*v.* Naunyn in Ziemssen's "Cyclopædia").

In Tamassia's experiments it was very rapidly produced. He injected 3, 4, 5, 6 gr. respectively into the rectum of four animals (dogs and rabbits); toxic symptoms occurred in about fifteen minutes, death in eight hours (the temperature falling 8° F.). In all four of the animals the kidneys, and in two of them the liver also, were in a state of fatty degeneration (*Medical Record*, January, 1878).

SYNERGISTS.—Arsenic is allied to phosphorus in its power of acting upon the blood (with advantage in small doses, in large doses with destructive effect), also in its action upon nutrition. Cantharides, oxygen, and stimulants have somewhat analogous stimulating powers. It is a curious speculation that ergot of rye owes its properties to the phosphoric acid it contains (Levi: *British and Foreign Review*, April, 1876).

Adjuvants are found in phosphoric acid, and in fatty and fleshy foods. Phosphoric acid has especially been shown to develop or augment the powers of phosphorus, probably from aiding in its solution and circulation (Personne). The brains of animals and the flesh of hogs are said to be rich in phosphorus, and *roast* food to retain more than *boiled*.

ANTAGONISTS—ANTIDOTES.—Hydrate of magnesia, or of lime, will neutralize the acid compounds of phosphorus, and carbon will absorb phosphorus vapor. Sulphide of carbon antagonizes the excitant action of the drug, as also do sulphuretted hydrogen, anæsthetics generally, and cyanides (Gubler). Nitrate of silver was recommended as antidotal by Bellini (*Medico-Chirurgical Review*, ii., 1875).

In an important experiment by Crocq, oxygen was used as an antidote, defibrinated blood charged with the gas being injected into the veins, with the effect of restoring to its normal condition the dark, pitch-like blood of poisoned animals (*British and Foreign Review*, ii., 1875).

But the two antidotes which claim special attention are sulphate of copper and oil of turpentine. With any soluble salt of copper, phosphorus forms a black phosphide, non-poisonous; and as copper sulphate is also a good emetic, it is specially available for cases when the poison has been taken by the stomach, and when the remedy can be given soon afterward. Five grains should be given every two or three minutes until free vomiting is induced, and then, either continued in smaller doses and with opium, or turpentine may be substituted.

If oil of turpentine be brought into contact with phosphorus at a suitable temperature, a crystalline white solid is formed—terebinthino-phosphorous acid—which is not poisonous. Kohler and Schimpf obtained it by adding gradually 2 lbs. of the oil to ¾ oz. of the element at 40° C., and the same substance has been obtained in the distillate from urine in cases of poisoning (*Pharmaceutical Journal*, March, 1873). To produce the desired result, the oil must come into *direct* contact with phosphorus in the stomach, and in the proportion of about 100 parts to each one of the

latter. Eleven hours is the longest time that has elapsed before the administration of the remedy in successful cases. Moreover, it is not every kind that will act well; the pure rectified oil, and much of that imported as German and American, do not form the crystalline acid, and hence a difference in the results of some observers. It is the crude, acid, French oil, or that which has been ozonized by long exposure, which gives reliable results. It is said also that milk lessens its good effect.

A case illustrating the value of both the antidotes recommended occurred in my practice some years ago. A young man (insane from overstudy for examination) swallowed some pieces of solid phosphorus, and, while his friends were gone for assistance, gashed his throat and body with a razor. When I saw him the most pressing need was to stay hemorrhage, and while doing this I sent for some copper sulphate and turpentine, giving him at once mustard and water. This and the copper produced good emesis, with rejection of a piece of phosphorus two inches long. I then began giving turpentine in milk (also in water), but still encouraged vomiting, because from the small pieces left in the patient's bottle of phosphorus more was thought to have been taken. Eventually two other pieces, 1½ in. and ½ in. long, were rejected, after having been in the stomach at least three hours. Several more doses of turpentine were given, and the patient made a good recovery, with the exception of some dyspepsia: he was seen afterward by Dr. Fuller, the family physician, and passed from under my care, but is, I believe, still living in an asylum. The case may be considered another illustration of the fact that large pieces of phosphorus are less dangerous than the finely divided substance; but I think real benefit resulted from the antidotes used.

A case is reported of a man who swallowed 120 match-heads, and then took turpentine to increase the effect. He did not vomit, but recovered (*Medico-Chirurgical Review*, ii., 1869, p. 555).

Other cases, cured by the same antidotes, are given in *Braithwaite*, i., 1872, p. 131, and in Sydenham Society's "Year Books," and *British Medical Journal*, i., 1878.

Therapeutical Action (Internal).—From what has preceded, it will be recognized that the value of phosphorus lies in its power of strengthening and giving tone to the nervous centres when their activity is impaired; also, since nerve-debility is a cause of many other besides what are called *nervous diseases*, a nerve-tonic of this kind has a wide field of usefulness, and is applicable not only in nerve-exhaustion and pain, but in many conditions of adynamia. Rabuteau, however, states an opposite view when he says: "I do not hesitate to assert that this poison has never cured anything up to the present time, and I would never prescribe it; it has always been useless" ("Elements," p. 211); while Beaumetz, A. Thompson, and others have recorded wonderful results from it. The truth probably lies between the two extremes, and

we must not forget that some failures may be accounted for by inactive preparations of a drug always difficult to dispense.

Neuralgia.—Eighty years ago von Lobel, a physician, related his cure from an inveterate cranial neuralgia (which was accompanied with debility and failure of mental and sensory power) by an ethereal solution of the drug. He took ¼ gr. every two hours, and (with one relapse) was restored to health in a short time, and after only a few doses. This experience was corroborated to some extent, and the remedy came into great repute, but was soon found to be a dangerous one and difficult to manage, and it gradually fell into disuse, no doubt owing to the largeness of the doses. A few years ago Mr. M. Bradley published a case of neuralgia of the chest-walls, rapidly cured by "tincture of phosphorus," after failure of all recognized remedies, and later he recorded other successful results (*British Medical Journal*, October, 1872). In the following year Dr. Slade King added testimony to its value in doses of $\frac{1}{30}$ to $\frac{1}{20}$ gr. (*Medical Times*), and Dr. Ashburton Thompson recorded forty consecutive cases either cured or relieved (*Practitioner*, 1873); Mr. Sanger, of Alfriston, referred to an equal number (*British Medical Journal*), and Dr. Hammond praised it in America (*Practitioner*, i., 1877).

Drs. Radcliffe and Broadbent may be cited also among those who early employed it with good results, the latter especially in "anginoid pain"—a *cardiac* neuralgia (*Practitioner*, 1875). It was found useful in cases connected with extreme general debility—whether from over-lactation, hemorrhage, or simple asthenia—in cases due to pregnancy, to cold, and to local irritation, such as carious teeth, and even to rectal cancer (Thompson). Anstie's experience was not so favorable.

I have myself seen much benefit from it in many of the above cases, also in *uterine neuralgia* occurring in sensitive patients, and induced either by protracted lactation, excessive sexual passion, or by mental or local causes. The severe pain is apt to come on just before or during the monthly period, and then $\frac{1}{100}$ to $\frac{1}{50}$ gr. should be given three or four times daily; during the interval the smaller dose should be given, and less frequently.

Intercostal Neuralgia.—For upwards of twenty years I have been accustomed to use phosphorus in this affection, and can speak favorably of its power. I have notes of fifty-six cases wherein the pain quickly subsided under this treatment, and did not, so far as I know, subsequently return. In some instances phosphorus succeeded where arsenic had quite failed. The dose was $\frac{1}{100}$ to $\frac{1}{50}$ gr. three times daily.

With regard to the dose of phosphorus in neuralgia and nerve-disorders generally, I may say that in my experience the comparatively large doses recommended by Dr. A. Thompson cannot be tolerated for any length of time by the system. They may seem at first to stimulate, or rather *over*-stimulate, the nerve-centres, but after a short time they de-

press in a disastrous manner; while the small doses of $\frac{1}{200}$ to $\frac{1}{50}$ gr., continued for due time, nourish and strengthen nerve-tissue, without any evidence of undue excitement. A therapeutical, and *not* a physiological action, is to be always desired.

Herpes Zoster.—In this affection, which is distinctly neurotic, I have found good from phosphorus, for it has in some instances quickly relieved the severe pain.

Facial Spasm.—Twitching of the facial muscles, especially about the orbit, often occurs in cases of neuralgia and of impaired nerve-power. I have known it markedly improved by phosphorus.

Nerve-Exhaustion.—Gubler found phosphide of zinc remove the sensation of fatigue after hard work, improve appetite and digestion, and conduce to sleep. He gave a $\frac{1}{2}$-gr. dose with an ordinary digestive pill at dinner-time; but such a dose is too large, and is very liable to nauseate. When the nervous system is jaded and below par, so that slight impressions are too deeply felt, and the nerve-controlling power is impaired, phosphorus has been found to supply what is wanting for a time; also, it has been said to improve intellectual tone in those subjected to either monotonous brain-work or to an unusual mental effort (Thompson). Dr. Broadbent early recorded some striking cases of this kind: one of "nervous break-down" in a city merchant, with insomnia, and extreme depression and incapacity for work, and another in which "epileptiform vertigo" was present in addition. Both got well "quickly and completely" under phosphorus (*Practitioner*, 1873).

In cases of *Chronic Exhaustion of Brain-Power*, or of general nerve-exhaustion consequent on chronic disease, small doses continued for a long time are advisable, and have been plausibly held to supply to the nerve-tissue a vital element in which it is deficient, and to improve its nutrition, just as Wegner showed that the drug improved the nutrition of bone; and certainly its supply, in some form, to nerve-tissue, is as necessary as that of iron to blood-corpuscles.

I have reason to believe that benefit may be obtained from phosphorus even when there exists evidence of atrophic change in the brain, of the nature of white softening or chronic fatty degeneration, with such symptoms as failure of memory and of self-control, loss of proper sensation and cerebral power generally. These are commonly associated with feeble heart-action, and with arterial degeneration, and may occur not only in advanced life, but as a consequence of wasting disease, chronic alcoholism, etc. I remember well a case of this kind in which epistaxis was a frequent symptom, and had proved rebellious to iron, acids, and other ordinary treatment in the hands of experienced men: small doses of phosphorus (ethereal tincture) improved the patient very much both as to brain and muscular power, but the symptoms always tended to recur on omission of the remedy, and he continued it for a long time with good results.

A suitable dose is $\frac{1}{50}$ gr. thrice daily for about a fortnight, and then it should be reduced to $\frac{1}{100}$ gr. or less, and should be taken for twelve to eighteen months, omission being made for about ten days in each month.

Although I do not find this experience to be general, yet it is not wholly singular, for Dr. Hammond also speaks of the value of the remedy in conditions of softening; he recommends similar doses given with cod-liver oil, or zinc phosphide in $\frac{1}{10}$ gr. doses.

Fatty Degeneration.—That a different action may be obtained from a different dose of the same medicine is an elementary therapeutical axiom in constant application, and it is, I believe, a clinical fact that phosphorus can relieve the symptoms which are usually associated with fatty degeneration, not only of the brain, but of other organs. I have notes of more than thirty cases in which fatty degeneration of the heart might fairly be diagnosed: the cardiac sounds were feeble, the impulse weak, the pulse slow, sometimes excited, irregular, soft, and compressible; with dyspnœa on exertion, and a sense of anxiety and tendency to syncope to a greater or less degree; arcus senilis sometimes present. After taking phosphorus for a few months, most of the patients were much relieved, and were able to move about without fear, and with comparative comfort. No doubt somewhat similar cardiac symptoms may be caused by nerve-exhaustion or gout; the absolute diagnosis of fatty degeneration cannot always be insisted on, and I do not wish to maintain that phosphorus reconstructs degenerate cells, but its acknowledged power over nutrition makes it reasonable to suppose that it can hinder or stop commencing degeneration, and especially improve the condition of the nervous system.

It is highly important to carefully proportion the dose to the necessities of each individual case, as some will take with advantage more than others. Where the heart-action has been very irregular, or the dyspnœa and syncopal feelings more than ordinarily troublesome, I have given $\frac{1}{30}$ to $\frac{1}{20}$ gr. occasionally; but these doses should not be given frequently, for fear of aggravating the symptoms. I prefer to give $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. twice or thrice daily. Not only in heart disease of the kind described, but in fatty degeneration of other organs, and in the form which threatens during typhus and some other acute diseases, phosphorus is worthy of attention.

For many years I have been accustomed to use it in such cases, and the improvement traceable to it is often remarkable. The smaller doses mentioned are to be preferred, in order to avoid irritant effects, and to get the system slowly, but more fully under the influence of the remedy; when this is done, the effect is more thorough and lasting.

Exhaustion of Fevers, etc.—The value of phosphorus in conditions of extreme exhaustion in advanced disease is one of the earliest recorded experiences of Kramer, Mentz, Leroy, etc. (1733–1798). They used it

in the muttering delirium and incipient coma of typhus, the collapse of malignant "bilious fever," and the profound depression of extensive pneumonia. Bayle says, "in every disease where death is imminent from failure of vital force without much structural alteration, phosphorus is indicated. We see this in severe continuous fevers during their last stage, whether they be caused by some miasm, typhus, plague, etc., or by 'spontaneous alteration of the blood,' as in adynamic or putrid fevers (so called); in such cases phosphorus reanimates vitality, furnishes nature the means of effectually resisting the disease, and eliminating its material causes by natural excretory outlets. It is indicated, secondly, in all acute exanthemata when eruption has disappeared suddenly, with aggravation of symptoms (measles, variola, erysipelas, low fever with exanthem); thirdly, in malignant pustule, where the disease has reached its acme and the vital power is almost extinct." Bayle adds that it is useful in chronic gout and rheumatism (which are relieved through profuse excretion of sweat or urine), and "all morbid conditions wherein it is proper to excite these secretions, and at the same time to stimulate vitality in a speedy and energetic manner" ("Bibliothèque de Thérapeutique," vol. ii.).

Powers so extensive as these have not been accorded to phosphorus by more modern writers, but Mr. Clay has illustrated its value in the collapse of variola (*Lancet*, ii., 1858, p. 315), and Dr. John Brunton in the adynamia of typhus and typhoid fevers, rapid improvement taking place under drachm-doses of the following solution: Tinct. phosph. æth. (gr. $\frac{1}{4}$ ad ʒ j.) ʒ iij., Spt. vini rectif. ʒ ss., Glycerini ad ℥ iss. About two grains were taken in the course of two days.

I have frequently prescribed phosphorus in the exhaustion of typhus and typhoid, and have sometimes seen remarkably good results from it; but, on the other hand, have been often disappointed, and cannot but consider it an uncertain remedy in such cases. I would place more dependence upon ammonia, camphor, and other stimulants of that class, but, if they failed, should then have recourse to phosphorus. Another use of the drug in fevers is to assist development of the specific eruption, *e.g.*, in enteric, scarlet fever, and measles, and within my own experience it has proved of service when the eruption has disappeared suddenly with the onset of serious symptoms.

Exhaustion of Generative System—Impotence.—In such conditions phosphorus has long had a reputation, and was much valued by early authorities, but modern experience has limited its powers. If the special exhaustion referred to be only part of a generally enfeebled state, it will doubtless improve as general tone and vigor improve, but this system is not to be stimulated apart from the others; indeed, if it were so, this might be a serious drawback to the ordinary use of the remedy. I may say, however, that in some of my own cases an irritable, weakly condition

of the sexual organs, traceable to previous early abuses or subsequent excesses, has been much benefited by steadily continued doses of $\frac{1}{200}$ to $\frac{1}{100}$ gr. thrice daily.

Spinal Irritation.—I consider phosphorus of greater value when this condition is connected with onanism than when arising from over-fatigue or other causes. The irritation is marked by local discomfort, a burning pain in the lumbar region, sense of fatigue and impaired walking power, mental distress, etc. In such cases it is essential that the patient exert moral control over himself, and that treatment be continued judiciously for some months. The remedy relieves the spinal pain and the mental depression, and thus indirectly tends to lessen abnormal sexual desire.

Disorders of Menstruation.—Patients with scanty, watery, and irregular catamenia sometimes suffer, about the time of the periods, from sick headache, and when this is the case a continued course of phosphorus increases the quantity and improves the quality and regularity of the menses, and the headaches frequently disappear. Phosphorus, like aconite, restores the discharge when suddenly interrupted by cold or fright.

When the discharge is not only too profuse, but watery in character, and rather delayed beyond the natural time, phosphorus is of considerable use, as it checks the overflow, relieves the backache, improves the mental depression, removes the nausea and vomiting so frequently attendant, and strengthens the general condition. It is also useful in profuse menstruation attended with excessive sexual excitement. The dose should rarely exceed $\frac{1}{100}$ gr. every two to four hours during the menses, and morning and night during the menopause.

Paralysis.—Cases of hemiplegia relieved by phosphorus are on record, but not from very reliable sources. It is contraindicated in acute irritative conditions, but in chronic stages should be tried, particularly if exhaustion be a prominent symptom. I agree, generally, with Lemaire, who has summarized the modern use of it for paralysis, and finds that, in local palsies after severe illness, or from anæmia or hemorrhage, it has a general tonic, stimulant power, but not a specific curative effect, and is always uncertain. In paralysis dependent on severe organic disease, tumor, or hemorrhage in the nerve-centres, it cannot, of course, be relied upon, nor in hysterical palsy, although, in the last-named, I have sometimes seen advantage from it, and Dr. Hammond speaks well of a combination of zinc phosphide with strychnia. It is commonly useless in old paraplegia, in sclerosis, and in lead-palsy; and Mr. Sanger is almost alone in reporting paraplegia and paralysis agitans cured by the drug. I have, however, known it relieve formication in paralyzed parts. It has been found of service in recent ataxy and in mercurial palsy (tremor), and its advantage has been distinct in *functional derangement with adynamia*, and in some slight structural lesions when inflammation,

fever, and cerebral excitement were absent (*Bulletin Général de Thérapeutique*, September, 1875). The dose recommended is about one milligramme ($\frac{1}{65}$ gr.). For intra-ocular paralysis it was used by Tavignot, externally and internally.

Tremor.—In alcoholic tremor, as well as in the mercurial form, and in partial paralysis of the same kind caused by arsenic, Dr. G. De Mussy has found advantage from four-milligramme doses ($\frac{1}{16}$ gr.) (*Lancet*, i., 1876).

Locomotor Ataxy.—Dujardin Beaumetz has advocated the use of phosphorus in ataxia, upon the strength of four partially successful cases, of which, however, the after-history is not given. His favorable observations have not been generally confirmed, though a patient said to be suffering from "progressive locomotor ataxy," unrelieved by bromides, strychnia, quinine, and iron, was able to stand and to walk after two months' treatment by phosphuretted oil (Hartley: *Lancet*, i., 1877), and some other scattered observations may be found. The malady exhibits, in its natural course, remission and improvements, partial, and lasting for a variable time, but sufficient to throw uncertainty on the action of any medicine, unless very carefully and frequently verified. This was instanced in one of eighteen cases of ataxy reported by Mr. Bradley (*British Medical Journal*, ii., 1878); the improvement observed might have been credited to the remedy, had not the patient relapsed afterward while under the same treatment. The others remained *in statu quo*. It is possible that, in these and similar instances, the dose was too large, or not continued long enough, and further observations should be made. Certainly, in some few cases I have seen much improvement during a prolonged use of phosphorus ($\frac{1}{100}$ gr.) or zinc phosphide, though I am not satisfied that it was really due to the drug.

Hysteria.—Nerve-power is impaired in this affection, the emotions not being under normal control; more or less neuralgia is often concomitant, and altogether it is a condition in which we should expect phosphorus to be useful, and instances of its value are on record. The cases benefited by it have been acute or chronic, dependent on sudden shock, or gradually coming on with increasing weakness and despondency; in either form a period of debility is liable to be followed by convulsive attacks. I do not undervalue moral and hygienic treatment; but, among medicines, phosphorus in doses of $\frac{1}{100}$ to $\frac{1}{20}$ gr. has proved efficient in my hands. When hysterical attacks are connected with delayed or suppressed menses, pain in iliac and lumbar regions, vomiting, palpitation, and general excitement alternating with depression, I have found this remedy regulate the menstrual periods and cure the hysterical symptoms.

Epilepsy.—In true epilepsy it has, like most other nerve-tonics, been used and commended, but evidence of its really preventing the attacks is contradictory. Broadbent found it useful in epileptiform vertigo (*Prac-*

titioner, viii.–x.), and Anstie observed it relieve the depression of epileptics and improve their temper and power of control (*Medical Times*, i., 1862). In the early period of the disease, when dependent upon sexual abuse, I have known phosphorus prove very beneficial. I remember especially the cases of two men, aged nineteen and twenty-three, whose attacks began soon after puberty, and who had taken large doses of potassium bromide without evident relief, and who became quite freed from their attacks during a course of phosphorus, and have continued free from them during the four and six years that have since elapsed. The dose was only $\frac{1}{100}$ gr. three times daily, which was continued (irregularly) for twelve or fifteen months.

Melancholia—Dementia.—Dr. S. W. Williams in this country, and Dr. Ford in America, have recorded their experience of phosphorus in these conditions. The six cases of the former physician were treated by $\frac{1}{30}$-gr. doses (Kirby's pills) twice or thrice daily, but only two could be considered relieved (*Journal of Mental Science*, 1874). Dr. Ford recognized improvement in fifteen cases of dementia (*American Journal of Insanity*, January, 1874). Dr. Judson Andrews had previously written in favor of *phosphoric acid* in different forms of insanity, but especially those tending to melancholia (*American Journal of Insanity*, October, 1869).

I have notes of thirteen cases of recovery from this distressing affection in patients between the ages of thirty-two and forty-five years, most of whom showed well-marked symptoms, such as despondency and depression, suicidal impulse, fear of solitude, loss of sleep, etc.: they looked haggard, with flushed face, and complained of cold, clammy skin, vertigo, and various disturbances of the digestive system. In addition to general treatment by exercise and different forms of bath, and the occasional use of nux vomica or aperients, I gave phosphorus, at first $\frac{1}{30}$ gr., afterward $\frac{1}{100}$ gr., thrice daily, with the result that all recovered in the course of two to three months. My experience of fourteen other cases between the ages of thirty-five and fifty shows, however, that it is an uncertain remedy, and although quickly beneficial in some cases, in others it is disappointing.

Pneumonia.—A simple pneumonia usually terminates favorably, independently of medicine, and requires at least no active interference; but, under certain conditions and complications, phosphorus has proved, in my experience, a valuable adjuvant. Thus, if at the commencement of an attack adynamia is very pronounced, this medicine is indicated. It is curious that the most amenable to its action seem to be adult subjects previously robust, and old persons. It is a matter of common observation that the nerve-power fails more rapidly in severe illness attacking such subjects, than it does in the young or the simply delicate. Some degree of biliary disturbance usually accompanies the early stages of

pneumonia, and so long as this does not assume a very aggravated form, I have found it a good indication for phosphorus treatment, and especially if prostration be extreme. Again, it is good in ordinary cases with difficult muco-sanguineous expectoration and very marked lowering of strength and evening exacerbations; also in later stages, when either pyrexia has subsided and the patient is left very feeble, and does not progress toward convalescence; or again, when red hepatization is complete, fever and prostration increase, and suppuration is imminent—although, when pus has actually formed, phosphorus is contra-indicated.

Dr. A. Thompson, speaking highly of the value of phosphorus in pneumonia, remarks that success depends much on the dose given, and in his opinion the better results of older practitioners were traceable to their use of full doses, toxic effects being less known and consequently less feared by them. He says that "no caution need limit the quantity of such a preparation as the tincture, the only limit to be recognized being improvement in the patient." He commonly orders $\frac{1}{12}$-gr. dose in the cases referred to, but I cannot agree either with this theory or practice; my best results have been obtained with $\frac{1}{200}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr. given every two to four hours.

I have also had good results from phosphorus in *chronic* pneumonia; but when it occurs in tuberculous subjects with tendency to hemorrhage, this drug should be avoided. In acute or chronic cases, complicated with *bronchitis*, phosphorus is less appropriate than other remedies.

Chronic Bronchitis.—In simple cases of this affection, when patients complain of a feeling of tension throughout the respiratory tract, and a hacking, dry, and exhausting cough, phosphorus is, however, often valuable.

Pleurisy. — In pleuritis with extensive recurrent effusion of dark, bloody-looking serum (as proved by aspiration), in patients whose blood has been impoverished by excessive and long-continued use of stimulants, I have found phosphorus as well as arsenic of much use in hastening absorption of the fluid, and giving tone to the nervous system.

Tuberculous Phthisis.—The action of phosphorus in this affection can only be considered palliative; but it can, at least, moderate some troublesome and irritating symptoms. I have used it in various doses in upwards of eight hundred cases of which I have record, and am satisfied that it does not cure advanced tuberculosis, but appears in many cases to arrest its progress, at least for a time; also to improve the condition of the throat and the voice, and to relieve the dry, harassing cough, the pain after food, and even the colliquative diarrhœa and night-sweats. It has also removed pleuritic stitches, and seemed to strengthen the general condition; on the other hand, its use is not free from danger, and requires caution, since it may induce obstinate hæmoptysis where there is a tendency to hemorrhage.

Chronic Diarrhœa, in children, with frequent watery evacuations, abdominal pains, depression, and emaciation, or the colliquative form, occurring, *e.g.*, in phthisical adults, has often in my hands yielded quickly to phosphorus. Sometimes it is well to give a few doses of Fowler's solution of arsenic in conjunction with phosphorus.

Intestinal Ulceration.—Phosphorus is useful in ulceration of the intestinal mucous membrane, the result of muco-enteritis, dysentery, or other causes, and especially when considerable prostration, restlessness, and emaciation are present. It is well, sometimes, to combine it with a course of arsenic.

Chronic Otorrhœa.—In some obstinate cases, common in strumous children, phosphorus is very valuable in stopping the discharge and giving nerve-tone and strength to the system generally. When glycerin of tannin and other astringents fail to permanently stop the discharge, a course of phosphorus, conjoined with the daily application of the tannin, will accomplish a cure.

Cutaneous Diseases.—The value of phosphorus in these maladies was mentioned by Cazenave, and in 1850 Burgess recommended it in psoriasis and in lupus. More recently Dr. Broadbent, inquiring how far the chemical analogies of drugs would guide to their therapeutical effect, was led to use phosphorus in the same class of cases as arsenic, and he recorded six cases of eczema and six of psoriasis treated by the former drug. The majority of these were relieved or cured ("Clinical Society's Transactions," vol. iv.).

Dr. Eames also reported successful cases under the same treatment (*Dublin Journal*, January, 1872), and Mr. Squire, recording in detail the course of psoriasis in a young girl, to whom full doses ($\frac{1}{10}$ to $\frac{2}{5}$ gr. per diem) were given for several weeks, concludes that the remedy was of much advantage, though not wholly curative by itself (*British Medical Journal*, ii., 1877); and it seems to me that in this case more allowance should be made for the change of air and diet, the girl having come from Wales to London.

In a case of Dr. Whipham's, whatever good was obtained in the first month of treatment was lost in the second, and in several cases within my own knowledge—severe and chronic cases, it is true—phosphorus was given without benefit. It would seem, then, that it is *uncertain* as a remedy, and, without denying its occasional power of relieving, I think, with Erasmus Wilson, that it is indicated rather for the impaired nerve-condition accompanying many skin disorders than for any direct influence upon the nutrition of the skin.

Lupus—Scrofuloderma.—In these forms of depraved nutrition theory would suggest that phosphorus might be useful, and Dr. Eames states that some cases have recovered under its use in from five to nine months.

Dr. Mackey has given it a fair trial in three or four instances of various

forms of lupus, and has found it improve the general condition, but without exerting any special influence over the local affection.

In rodent and cancerous ulceration, however, I have known it relieve the burning and other pains, and also check discharge and lessen exhaustion.

Pemphigus—Acne—Boils.—Cases of cure from each of these disorders, under the use of phosphorus, have been recorded (*British Medical Journal*, ii., 1876). In *pemphigus*, arsenic, as a rule, is to be preferred, and *during an eruption of boils*, phosphorus is only indicated if the pus becomes thin and sanious, and the nerve-power unusually depressed.

A severe case of acne indurata under Dr. Eames seems to have improved remarkably, but the few cases in which I have used it did not derive benefit from it.

Abscess (*Fetid*).—In simple cases of abscess, antiseptic surgery, carefully carried out, generally proves successful; but, should it not do so, and should the pus become fetid and watery, and hectic fever appear, with rapid failure of strength, then $\frac{1}{100}$ to $\frac{1}{50}$ gr. phosphorus should be given every two to four hours, and I have seen this produce most favorable results.

Bone Disease—Rachitis—Fracture.—In cases of fracture, resection, and transplanting of periosteum, Wegner found that small, continued doses of phosphorus stimulated the growth of new bone, especially in young animals; also that ossification in the fœtus was promoted by giving phosphorus to the mother. It is noteworthy that he obtained similar results, though less in degree, from phosphoric acid and oxy-compounds of phosphorus, but not from the amorphous element, nor from lime phosphate.

I have myself seen good results from phosphorus in ordinary *caries* of bone, and again, in cases of *abscess* connected with necrosed bone, it lessens suppuration and hastens the separation of the sequestrum; given during pregnancy, it relieves the dental caries and neuralgia often incidental to that state, and I have given the hypophosphites successfully in such cases. It may be presumed that phosphorus, and such preparations of it, would also improve the nutrition of the fœtus in weakly subjects, and I think they might often be used with advantage in chronic rachitis.

Leucocythæmia — Pernicious Anæmia — Lymphadenoma.—It is in such blood—and gland—disorders, which are essentially of serious, if not fatal import, that phosphorus has been recently employed, and Dr. Broadbent, one of the first to recommend it, offered some evidence in its favor. A boy with "essential anæmia," prostration, diarrhœa, yellow, waxy face, etc., recovered very quickly under phosphorus capsules, and remained well for some time. Another case of "leucocythæmia," treated in the same manner, got inflamed spleen, "apparently from very rapid blood-formation" (*Practitioner*, i., 1875). In a woman with lymphadenoma,

having symmetrical enlargement of cervical glands, anæmia, dyspnœa, etc., steadily getting worse for some time, "complete recovery took place" after taking phosphorus (*British Medical Journal*, ii., 1876, p. 792). In two other cases—one very far advanced, the other chronic—the same remedy was successful. Some support was given to Dr. Broadbent's conclusions by a case, under Dr. Wilson Fox, of "leukæmia splenica" occurring in a man, aged thirty-seven, in University College Hospital, for, when extremely enfeebled, he began to take $\frac{1}{60}$ to $\frac{1}{30}$ gr. doses, and after three months' treatment was greatly improved; he died, however, in the following year (*Lancet*, ii., 1875).

If we add to these cases one of leukæmia (Dr. Gowers), in which the use of phosphorus was followed by diminution in size of glands, and lessened anæmia (though albuminuria and death afterward occurred), it will be seen that the evidence in favor of phosphorus is not strong, while many cases of its failure are on record. Dr. Moxon objects even to receive Dr. Fox's successful case as one of leukæmia, because the white corpuscles in the field were "only twenty to thirty," and refers to about thirty cases of his own ("pernicious anæmia," apparently), all unsuccessfully treated by phosphorus (*British Medical Journal*, ii., 1876, p. 792).

At the meetings of the Clinical Society at which this subject was discussed (November, 1876), Dr. Greenfield and Dr. Goodhart related unsuccessful cases, and Sir William Jenner referred to three of "splenic leucocythæmia," in which the remedy seems to have had a really fair trial without any good result. The question was even raised whether it might not be responsible for some fatty degeneration found post-mortem; but, without laying stress upon that point, the general conclusion of competent authorities, both at that time and since, has been adverse to the value of phosphorus in such cases.

It would seem, perhaps, to offer a better prospect in cases of *lymphadenoma* than of *leukæmia*, and especially in early cases, and more evidence must be collected before we can rightly estimate the true power of the drug. I have already referred to the increase of red blood-corpuscles, reported by Dr. Gowers, under the use of phosphorus; this was in a case of "lymphoma," and the increase in one month was from 52 to 66 per cent., and in another month to 74 per cent.; $\frac{1}{30}$ gr. was taken three times and then six times daily—no other drug was given, nor were the circumstances of the patient altered. The pathology of these maladies is, however, still very obscure, and they are not well defined one from the other. Greater clearness in their diagnosis and prognosis must be expected to precede therapeutic advance; but we may say this, that much more benefit has been already recorded from *arsenic*, both in pernicious anæmia and in lymphadenoma, than from phosphorus. The two remedies are doubtless allied, but the former claims much more reliance than the latter.

Bronchocele.—In nine cases of bronchocele (fibrous) I have made trial

of phosphorus in varied doses, but without good result. Dr. Leech (Manchester) has sometimes seen the growth subside under the use of this drug, after iodine had failed (*British Medical Journal*, i., 1874), and it *may* occasionally prove a resource. Dr. Moxon has pointed out that glandular tumors vary in size, not only under various remedies, but sometimes without apparent cause.

PREPARATIONS AND DOSE.—*Phosphorus:* dose, $\frac{1}{100}$ to $\frac{1}{10}$ gr., less or more. *Oleum phosphoratum* (made with oil of almonds previously heated to 300° F., to destroy organic impurities); 5 min. contain $\frac{1}{32}$ gr.: dose, 3 to 10 min. *Pilula phosphori* (made with tolu and yellow wax); 5 gr. of the pill contain $\frac{1}{18}$ gr.

An exception has been taken to these officinal preparations: to the *oil* as disagreeing with the stomach, to the *pill* as being too concentrated, or not soluble enough; and many other formulæ for the medicine have been published (*British Medical Journal*, i., 1879, etc.). It is commonly agreed that the free unoxidized element will produce effects which none of its chemical compounds can do, and it is desirable, therefore, to give it in its pure, unaltered state. It cannot be finely divided without risk of oxidation, and the vehicles of fluid preparations, especially oils, are apt to disagree with the stomach.

Devergie, Solon, and others state that a solution in any *vegetable oil*, exposed to light and air, is apt to decompose, with partial conversion of the element into hypophosphorous acid, which has toxic properties, and hence some untoward accidents that have occurred with the phosphorated oil. A solution in *cod-liver oil* is not liable to this, but Dr. Broadbent finds it soon becomes oxidized, and loses its effect.

An *alcoholic tincture* may be prepared by adding phosphorus in excess to boiling alcohol quite free from water; this will take up 1 gr. in 6 dr. 20 min. (Thompson), and, if carefully kept from light and air, will remain unchanged for some weeks. As the result of many observations, Dr. A. Thompson recommends 3 dr. 10 min. of this tincture (=$\frac{1}{2}$ gr. phosphorus) to be added to 1 oz. 40 min. of anhydrous glycerin, with 5 min. of spt. peppermint, and he finds this more stable and less disagreeable than any other form.

I myself prefer an *ethereal tincture*, in which 1 gr. phosphorus is first dissolved in 1 dr. of pure ether; and this solution, after standing some days, is mixed with pure alcohol, so that a proportion of 1 gr. in 500 min. is preserved. From 2½ to 5 or 10 min. of this ($\frac{1}{250}$ to $\frac{1}{100}$ or $\frac{1}{50}$ gr.) are readily taken, mixed with water, and the preparation is stable enough for all practical purposes. It should not be kept longer than three to five weeks.

Chloroform, which dissolves 1 per cent. rather quickly, has been used by M. Beaumetz as a vehicle, in capsules or in wine; but it is nauseous, and not well borne. *Bisulphide of carbon* is really the best solvent yet

known for phosphorus, but its depressant and sometimes toxic effects contra-indicate its use. *Water* will take up, after agitation, a minute but uncertain amount of phosphorus, and it is not practically available as a medium for it. *Capsules* or "perles," containing $\frac{1}{60}$ to $\frac{1}{30}$ gr. in the form of phosphorated oil, are carefully prepared by Morson and other eminent pharmacists, and have been preferred by many physicians. They should be given after meals, but, even so, are not free from risk of causing gastric irritation. *Pills* may be made either with the drug reduced and powdered, or with a solution. Mr. Batten recommends pills with white wax; Mr. Gerrard with resin; Dr. Radcliffe uses suet. I do not like the pilular form; but, if it be adopted, oleum theobromæ is the best medium, though not easy to manipulate (Martindale).

The *phosphide of zinc* is a good form for administering in pill. Lemonade should be given at the same time. Dose: $\frac{1}{20}$ gr. to $\frac{1}{2}$ gr. The latter dose may nauseate.

[None of the foregoing preparations have as yet been admitted into the U. S. Pharmacopœia.]

IODUM—IODINE, I,=127.

Iodine occurs in the form of iodide, with magnesium and sodium, in sea-water, and in many mineral waters, such as those of Kreuznach, Cauterets, etc.; also in sponges and sea-weeds, in water-cress, beans, potatoes, etc. Molluscs, and the liver of the cod and other fish, contain iodine, and in the human organism minute quantities are commonly found.

PREPARATION.—Iodine is prepared from kelp, the residue of burnt sea-weed, soluble iodides being extracted by water, treated with sulphuric acid, and distilled with manganese oxide. Free iodine volatilizes and is condensed in receivers—$2HI$ (hydriodic acid) $+ MnO_2 + H_2SO_4 = MnSO_4 + 2H_2O + I_2$.

CHARACTERS AND TESTS.—Iodine forms heavy, dark, glistening scales, which stain yellow or brown, and have a peculiar, irritating odor. It is volatile, rising in violet-purple vapor at 400°. The sp. gr. of this vapor is 8.7, that of the crystals 4.9. It is soluble in alcohol, ether, and chloroform, and in water containing salt or iodide of potassium, but very slightly soluble in pure water (1 part in 7,000). The best test for free iodine is starch solution, which forms with it a dark blue iodide. In testing an alkaline iodide, nitric acid or solution of chlorine must be added before the starch, which should be cold, for the iodide loses its color on heating. The addition of caustic alkali also decolorizes the solution, iodide and iodate of the alkali being formed—$6I + 6KHO = 5KI + KIO_3 + 3H_2O$. Iodine is closely related, chemically, to bromine and chlorine (Halogens).

It has a stronger affinity for oxygen than these latter; but, for all other elements besides oxygen, a weaker affinity.

Compounds of Iodine.

POTASSII IODIDUM—IODIDE OF POTASSIUM, KI,=166.

Preparation.—(1) By adding iodine to liquor potassæ in slight excess, as indicated by a pale brown color of the solution. (2) The resulting mixture of iodide and iodate of potash is then heated with finely powdered charcoal, which deoxidizes the latter salt, so that iodide only remains: it is dissolved out and crystallized.

(1) $6KHO+6I=5KI+KIO_3+3H_2O$.

(2) $KIO_3+C_3=KI+3CO$.

Characters and Tests.—Occurs in white crystals, usually cubical and opaque, but sometimes octahedral and transparent. When pure these are odorless, but they commonly have some scent of free iodine, and if this is present they are tinged more or less yellow. The taste is saline. It is very soluble in water and in six parts of rectified spirit. Nitrate of silver precipitates a pale yellow iodide of silver, insoluble in ammonia. If this liquid be then acidified with nitric acid, no precipitate should occur; if it does occur, chlorides are present. The most important adulteration—not, however, a very frequent one—is the iodate of potash, and this is detected by its insolubility in rectified spirit, and also by the blue color developed on adding prepared starch and a little acid, *e.g.*, tartaric.

SODII IODIDUM—AMMONII IODIDUM (*not officinal*).

The iodides of sodium and of ammonium are prepared in a similar manner to the last described, and have similar characters, and may be tested in the same way.

IODOFORMUM—IODOFORM, CHI_3,=394 (*not officinal*),

Is a teriodide of formyl, and may be prepared by adding chlorinated lime to an alcoholic solution of iodine, heated to 104° F., till the liquid ceases to assume a red color. Confused crystalline masses of iodate of lime and iodoform precipitate on cooling; the latter is dissolved out by boiling alcohol, and deposited in small, pearly, yellow crystals of sweetish taste and penetrating, characteristic odor. It is insoluble in water, but soluble in boiling spirits (10 parts), ether (20 parts); also in chloroform, bisulphide of carbon, and oils; partially volatilized by heat; contains nine-tenths of its weight of iodine (Bouchardat).

Absorption and Elimination.—Iodine may be absorbed to some extent by the unbroken skin, if the local inflammation excited be not too severe. A dilute solution is therefore better absorbed than a strong, irritant tincture. M. Sée maintained that the unbroken skin would not absorb iodine at all, and that any systemic effects following its application were due to absorption of the vapor by the lungs (*Medical Times*, i., 1874), but I believe the facts are as above stated. If a limb be painted with tincture of iodine, and covered with oil-silk, drops of colorless liquid may be found upon it after a few hours; this liquid contains the drug altered in some way by the perspiration (Gubler), and a similar alteration possibly occurs before its absorption. The drug may certainly be absorbed by the skin in a bath containing iodine and iodide of potassium; nor is there any question as to its free absorption from serous and mucous membranes. Iodide of potassium and other alkaline iodides are not absorbed as such, even when applied to the skin continuously in lotion or ointment; but, after being decomposed by the acids of the perspiration, or of lard, etc., they evolve free iodine, which may be absorbed, as proved by its appearance in the urine (Rabuteau). Iodide of ammonium is the alkaline salt most readily decomposed, but iodoform parts with its iodine still more readily (*Lancet*, i., 1863). Baehrach applied compresses with iodate of potash solution, 2½ per cent., to the limbs, and in healthy subjects found iodine in the urine after fifteen minutes—in fever patients only after an hour or more (*Centralblatt für Medicin*, ii., 1879). By *mucous* surfaces these compounds are easily absorbed; thus, when a suppository containing 20 gr. of iodide of potassium was placed in the vagina, 18 gr. were absorbed in twelve hours; glycerin diminished the rate of absorption, while a little free iodine increased it (*British Medical Journal*, i., 1878, p. 897). *Serous* membranes absorb iodides still more rapidly.

Taken into the stomach in small or moderate doses, iodine coagulates and combines with albuminous material, and is probably taken up in part as an albuminate, though a larger proportion combines with the soda of the gastric juice, and becomes iodide of sodium before being absorbed. Rabuteau thinks this combination with sodium occurs, to some extent, in the blood.

Alkaline iodides are either absorbed unchanged, or as iodide of sodium.

Högyes has recently published observations on the absorption of iodoform. He states that, if introduced in an undissolved condition, the first step is its solution in whatever fatty matter may be at hand, *e.g.*, the chyme in the intestine, and oily constituents of organic liquids in subcutaneous tissue and serous cavities. The oily solution of iodoform next gives up its iodine to any albuminous principle present. The iodide of albumen thus produced is speedily taken up into the blood, while a few

minute coagula and oil-globules are left behind. The iodine is gradually eliminated from the system in combination with potassium or sodium (*Archiv für Exp. Pathologie und Pharmak.*, Bd. x., Hft. 3, 4).

Metallic iodides, such as those of iron, lead, or mercury, are decomposed, and also form iodide of sodium, which appears in the urine, while the metal passes by the bowel, or is deposited in the tissues. Absorption of iodides seems to be markedly promoted by ozonic ether (Day: *Medical Times*, i., 1871), by ammonia, and some other stimulants. Both iodine and the alkaline iodides are readily and rapidly eliminated by the different secretions, and may be detected in the saliva, the buccal and bronchial mucus, the tears, the milk, the perspiration, the urine, etc. R. W. Taylor has reported evidence of elimination of iodine by the skin in the case of a man with pityriasis, who took large doses of the potassium salt while wearing a starched shirt; he had profuse perspirations, and a dark coloration appeared on his back. After continued use of *iodoform* internally, iodine is clearly eliminated by the skin, as proved by the characteristic and unpleasant odor of the perspiration (Binz).

It would seem that almost all the iodine taken passes by the urine, for Scharlau recovered from that excretion 345 centigrammes out of 350 taken (Stillé). According to Melsens, very little can be traced in the fæces; he suggests that the iodine that is excreted into the intestine is taken up again by the lining membrane before it reaches the rectum. Rabuteau found a small quantity in the fæces, so long as it was present in the other secretions; if diarrhœa occurred, the quantity was notably increased.

The *rapidity* of elimination varies with the quantity taken, a large dose giving evidence of its passage very quickly. Ranke found traces in the urine three and a half minutes after administration, and even sooner in the saliva. Nothnagel also found it early—in ten minutes in the latter secretion. Richardson found it in the urine within one minute of injecting tincture of iodine into an enlarged bursa, and, three minutes after breathing iodide of ethyl, iodine could be detected in the urine. It is an important practical point that elimination of this drug is complete sooner than that of many others. Dr. Balfour noted that even if large doses of iodide of potassium had been taken for many weeks, their elimination was complete within three or four days after ceasing to take them (*Edinburgh Medical Journal*, 1868). Dr. Duckworth, after a dose of 4 gr., found iodine in the saliva in five minutes, in the urine in twenty-five minutes; after twelve hours' interval it was still to be detected in both secretions, but after thirty-six hours in neither ("Bartholomew Hospital Reports," vol. iii.). Rabuteau, after 15 gr., found traces in the urine for three days; after 150 gr., for ten days; not afterward. The greater part was eliminated during the first day, little passed on the second, and scarcely a trace on the third; in the dog, elimination was somewhat slower. Claude Bernard, giving iodide of potassium, ceased to find it in

the urine twenty-four hours afterward; that he detected it in the saliva for three weeks must be considered exceptional. Speck has stated that in Bright's disease the kidneys do not eliminate iodine, and Dr. Duckworth could not detect it in one case after giving 10 min. of the compound tincture; but 3 gr. of the iodide of potassium gave evidence of its presence, only much later than usual, namely, one, two, or three hours after administration.[1] Baehrach, giving moderate doses of iodate of potash by the mouth to healthy subjects and to fever patients, traced the drug in the urine of both within fifteen minutes; but, on injecting it under the skin, elimination in the former occurred in five minutes, but in the latter forty minutes later (loc. cit.).

As will be noticed again under therapeutical action, iodides have a remarkable power of eliminating with themselves various metals and possibly organic poisons previously circulating in the blood or deposited in the tissues.

Physiological Action (External).—Locally applied, iodine in tincture, or strong aqueous solution, acts as an irritant or caustic. It stains yellowish brown, permeates and destroys the epidermis, and, if it reaches the true skin, causes severe heat and prickling, sometimes serous effusion and vesication, followed by desquamation or superficial scarring.

Volkmann and Schede found that, a few hours after the application of iodine, the white blood-corpuscles had escaped from the neighboring vessels to such an extent as to give, under the microscope, an appearance of suppuration; disintegration and fatty degeneration of tissue-elements also occurred, and prolonged applications to the limbs of rabbits caused periostitis. Iodine has marked antiseptic and antizymotic power, and is fatal to the lower forms of life, both animal and vegetable.

Its vapor when inhaled, undiluted and in sufficient quantity, causes heat, irritation, and cough, and sometimes has occasioned bronchitis and hæmoptysis.

Frictions with iodide of potassium sometimes produce local irritation and an acneiform eruption.

It has been stated that iodoform does not cause local irritation, but I have known it to do so when applied to abraded surfaces, especially inflamed ulcers; in ordinary cases it has some anæsthetic effect.

Physiological Action (Internal).—*Mucous Membranes.*—The earliest and most marked evidence of the constitutional action of iodine, whether taken by the mouth or injected hypodermically, is furnished by irritation and catarrh of the mucous membranes. If iodine itself be used, as in the form of tincture, there is more liability to *local* irritation of the

[1] Iodine may be detected in any secretions by white starched paper, which should be moistened with the liquid and then touched with nitric acid containing some nitrous acid: blue iodide of starch will be developed.

mouth and stomach than with the alkaline iodides, but the *distal* mucous irritation is the same with all forms of the drug. It is shown mostly in the throat and bronchi, the nose and eyes—parts that are all exposed to contact with carbonic acid gas, which it is supposed decomposes the iodide salt as it is eliminated, so that free iodine exerts its local irritant effect (Rabuteau). Others trace a similar decomposition to contact with ozone in the blood or in the air (Buchheim and Kämmerer: Virchow's *Archiv*). The irritation shows itself by pain and sense of pressure over the frontal sinuses, œdema, prickling, and heat about the nose and eyes, with sense of stuffiness and serous discharge like that of ordinary coryza. The dose that will produce these symptoms varies much with different persons, some being acutely affected by 1 or 2 gr., others not by 10 or even 20 gr. continued daily for a long time.

Circulatory System.—Iodine and iodides, especially the former, stimulate this system, rendering the pulse fuller and more frequent, dilating the capillaries, and increasing heat in the extremities.

After toxic doses, first palpitation and flushings, afterward faintness, pallor, and collapse occur, and Benedict concluded, from observations on batrachia, that both cardiac action and respiration were paralyzed (Schmidt's *Jahrb.*, Bd. cxv). Högyes reports a similar conclusion as to the action of iodoform on dogs, cats, and rabbits (*Medical Record*, May, 1879).

The blood itself does not seem to be affected unless it be rendered more fluid, and disposed to exude, for a form of purpura—"iodic purpura"—has sometimes occurred under the use of iodide of potassium.

Dr. T. C. Fox records an illustration in an adult with syphilide, and convalescent from rheumatic fever. After the second dose of 5 gr., a copious eruption of purpura came out on the arms and legs; this gradually faded and again recurred while the medicine was continued. The eruption came again under each of the alkaline iodides, especially the ammonium salt; iodism occurred at the same time, but the syphilide got well; there was no evidence of renal or other organic disease (*British Medical Journal*, i., 1879). Dr. Stephen Mackenzie attributed fatal purpura in an infant to one dose of 2½ gr. of the same medicine, but, in his case, the sequence is not so clear as in some others alluded to by him (*British Medical Journal*, i., 1878). Dr. G. Thin, after microscopic examination of eruptions caused by iodide, asserts that the neighboring capillaries are blocked and their walls altered, but the patient from whom the specimens were taken was syphilitic (*Medico-Chirurgical Transactions*, 1879).

Whatever the pathological processes may be, I am satisfied that tincture of iodine is liable to cause hemorrhage from various organs, especially in phthisical subjects, and in those with uterine congestion. Kness has observed hemorrhage from the lungs and uterus in poisoning by iodide of potassium (*British Medical Journal*, i., 1879), and extravasations of

blood have been found post-mortem in animals poisoned by iodoform (*Medical Record*, May, 1879, 182). We are not yet able to reconcile this hemorrhagic tendency with the clinical results obtained in the treatment of aneurism by iodide of potassium.

Nervous System.—Much disturbance of the nervous system sometimes follows the full action of iodine. It is marked at first by excitement, with restlessness, tremor, anxiety, and insomnia; but this state is liable to be succeeded by feebleness and depression. Toxic doses have caused violent headache, and sometimes convulsion. Rilliet described neuralgia, tinnitus, disturbed intellect, and convulsion, as prominent symptoms in some cases of iodism. Altered vision and paralysis were noted by Brodie. "Occasional hyperæsthesia and temporary palsy of lower extremities" occurred in a man who was taking very large doses (90 gr. thrice daily) of iodide of potassium (S. A. Lane: *Lancet*, ii., 1873). Such symptoms, however, must be considered rare. H. Wood states that he has only seen the nervous system affected once, in his experience, even "with enormous doses," and then the patient, who had been taking 270 gr. daily, became "intensely sleepy and stupid," as if under the influence of *bromide.*

More complete observations have been made upon the action of *iodoform* on the nervous system. Maître compared the effects to those of alcohol. After moderate doses—½ to 1 gramme—a dog either lay at rest, or, if made to rise, staggered and fell; next day it seemed well. After 3 or 4 grammes, intense excitement set in, with quickened circulation, convulsive contraction of limbs, and opisthotonos like that of strychnine. These are symptoms as of iodine in the circulation, and the odor of this substance was strongly marked in the breath. It would seem that, when not dissolved in the blood, iodoform acts as an irritant on the nervous system, but when completely soluble it induces muscular relaxation with insensibility (acting like a narcotic). Maître was one of the first to record its power of relieving nerve-pain (Bouchardat: *Ann.*, 1857). Righini, considering its chemical relations with chloroform, argued that it should possess anæsthetic power, and proved that it did so to some extent; but its local effect, when directly applied, is much more marked than its general effect when taken or inhaled. Twenty grains placed in the rectum are said to destroy sensibility in the sphincter, so that defecation is not felt (Morétin).

Franchino corroborated the fact of local anæsthetic action, and produced some amount of similar effect on the general system in dogs, birds, and rabbits, by making them breathe 2 grammes of iodoform vaporized by means of bellows in a closed chamber: a stage of excitement with muscular contraction was followed by sedation and anæsthesia for five or ten minutes; then gradual recovery. Binz, however, could not obtain so marked a result as this, which he attributed in part to the carbonic acid confined in the chamber (*Archiv für Exper. Pathologie:* Klebs, vol. viii.,

1877). McKendrick, comparing the drug to chloral, found that 10 gr. dissolved in about 1 dr. of alcohol, and injected under the skin of a rabbit, produced profound sleep for four hours, and 12 gr. destroyed life; but, again, Binz failed to verify this result, and attributed the sleep mainly to the alcohol. In his own experiments, 2 grammes in oily solution, administered subcutaneously to dogs and cats, produced but moderate sleep in the course of an hour, and 3 grammes impaired the functions of the brain and spinal cord, without being necessarily fatal. He concludes that moderate doses exert some narcotic effect, especially on dogs and cats, but not so much as former observers thought, and that toxic doses kill by general paresis, with lowering of temperature (*Edinburgh Medical Journal*, 1874).

Högyes, from recent observations made in order to reconcile the discrepancies in the above statements, states that large doses cause marked drowsiness in the dog and cat, not in the rabbit; also that during the somnolence reflex irritability is not much interfered with. Toxic doses cause death by gradual paresis of circulation and respiration (*Medical Record*, May, 1879).

Binz experimented also with the *iodate of sodium*, and found that in rather large doses this salt caused narcosis in animals. It proved especially poisonous to the respiratory and cardiac centres, and he suggests that both this salt and iodoform are decomposed and liberate iodine in the brain and cord.

Digestive System.—Iodine has a pungent taste, and in small doses causes heat and stimulation of stomach, with some increase of appetite. A dose of more than 1 gr. usually causes sickness, and 5 gr. give rise to salivation, pain in the abdomen, and diarrhœa; large doses may cause glossitis, local inflammation, and ulceration. Vomiting, burning pain, spasm, choking sensation, and impairment of the special senses, were symptoms noted by Mr. Bainbridge after the taking of 1 oz. tinct. iodine, *British Pharmacopœia;* oil was given, and recovery occurred gradually (*Lancet*, ii., 1875).

It is remarkable that iodoform, though containing so large a percentage of iodine, does not usually irritate the gastric mucous membrane, unless in toxic doses. The alkaline iodides readily disorder the stomach in many persons, and though at first they may increase appetite, they afterward impair it. Small quantities are apt to constipate, but, if continued they produce diarrhœa, with liquid, slimy stools. At times, gastric irritation and catarrh are the only marked symptoms of iodism (Rilliet). Leroy (Brussels) has adduced evidence to show that when gastric pain is caused by iodide of potassium, it is really due to adulteration with iodate (*Medico-Chirurgical Review*, ii., 1857). Mialhe endorses this, and Melsens considers such adulteration dangerous; five dogs were poisoned by it ("Mémoire," Brussels, 1865).

Rabuteau points out that either of the salts separately is unacted upon by weak hydrochloric acid, while their mixture is quickly decomposed by it, with liberation of free iodine; also, if fresh gastric juice be mixed with starch in test-tubes containing the one iodide, and the other iodate, no blue reaction occurs till the contents of the two tubes are mixed, implying that free iodine is the irritant agent in the impure salt, and that a pure alkaline iodide is non-irritant. Practically, however, I am satisfied that as pure an iodide as is obtainable will produce gastric irritation in some subjects. In the case of all iodine compounds, such irritation may be avoided or lessened by giving them freely diluted, and shortly after food.

Glandular System.—It is commonly held that iodine stimulates the absorbent glands to increased action. This may be an indirect effect consequent upon its breaking down and rendering more susceptible of absorption certain kinds of tissue. It may be connected also with its quickening capillary circulation in the secretory glands.

The salivary glands and the pancreas, and possibly the lachrymal glands and those of mucous membrane and the testes, have their secretion increased by it. Rutherford concluded that the bile was not affected in quantity (*British Medical Journal*, 1879).

The secretion of milk is usually lessened under the influence of iodides, and may be almost wholly prevented by small doses commenced soon after delivery. If already established, it may be suppressed by the same treatment if the infant be not placed to the breast (Morris: *Lancet*, ii., 1864). There are, however, some observations to the contrary, *e.g.*, those of Lazansky (*Medical Record*, 1878), who states that iodine does not affect the secretion; and certainly it may be given to syphilitic nursing mothers without stopping the flow of milk, when this has been established for several months.

Whether iodine can cause atrophy of true glandular structure is an important question which is not yet decided in the affirmative, though Rilliet accepts its truth in the case of the testes and mammæ. Moisisovitz states that iodine has this effect, but not the iodides; he refers to eight hundred patients (Canstatt, 1866).

Certainly large quantities have been given without any such occurrence. Rabuteau gave to a woman, in the course of six years, 3 *kilogrammes* of iodide of potassium, yet the breasts were not at all affected by it; and Velpeau never observed wasting in fifteen thousand cases treated by him (*Medico-Chirurgical Review*, ii., 1860). On the other hand, one case of wasting of the testes is recorded, but is not convincing (*Philadelphia Medical Times*, iv., 661). An enlarged and hard gland will grow less under these remedies from absorption of hyperplastic material, and even a healthy gland may grow smaller from absorption of fat or epithelial products; but, so far as I have seen, the breasts, etc., recover their natural

appearance on omission of the remedy, which they would not do if the gland-structure were actually destroyed.

Cutaneous System.—Various forms of skin-eruption may follow the internal use of iodine or the iodides, the most usual being allied to acne in appearance, and (according to T. Fox) in pathology also, that is to say, connected with irritation of the sebaceous glands. Dr. Thin denies this, and connects iodic rash with alteration of the capillaries, but apparently rests his opinion upon a single (syphilitic) case (*British Medical Journal*, ii., 1878).

Dr. Duckworth did not find the sweat- or hair-glands affected, and speaks of the rash as a "vesiculating dermatitis" (*British Medical Journal*, i., 1879). The pathology is probably not alike in all cases.

The ordinary rash is at first papular and then becomes pustular, and affects especially the face, head, and back; sometimes an erysipelatous blush is produced, sometimes bullæ, ecthyma, or anomalous pustules, (Hutchinson), and not uncommonly petechiæ, purpura, or hemorrhagic effusion may be met with, as already mentioned. Much œdema of the eyelids sometimes occurs. The irritant effect upon the skin may be much controlled by arsenic.

Genito-urinary System.—The genital system is stimulated by iodine, sexual desire being increased under its use (Jörg); an increased flow of blood to the uterus is sometimes determined by it. If the iodide of potassium has a similar effect, it is much less in degree.

The effect of either preparation upon the urine is variable. Begbie speaks of iodide of potassium as one of the best diuretics (*Lancet*, ii., 1875), while Handfield Jones, out of six cases observed, found the secretion increased in three, but diminished in two (Beale's *Archives*, No. 3). Rabuteau observed no diuresis from 15-grain doses. Wöhler, giving iodine to a dog, noted increase of urination, but only in proportion to increased quantity of water drunk (*Zeitschrift*, 1824). Bassefreund, from observations on himself, concluded that the urine in healthy persons was not augmented under iodides; at first it was rather lessened in quantity (Canstatt: *Jahrb.*, 1859). Very large doses may irritate and congest the kidney, and induce albuminuria, in which case the amount secreted would naturally be lessened (Gubler). Mr. Hutchinson "suspects that iodides may cause Bright's disease" (*Lancet*. ii., 1876). Dr. Simon found that albuminuria occurred in the majority of children that had tincture of iodine externally applied, whether to the scalp, the chest, or the knee (*British Medical Journal*, ii., 1876), although, from the analyses of Dr. Ord in a case of iodine-poisoning, the urinary precipitate in such cases would seem to be mucin rather than albumen. As remarked by Mr. Spencer Wells, the alkaline iodides have some power in dissolving uric acid, but this is due probably to the alkali rather than the iodine. H. Jones obtained very discordant

results from iodide of potassium; in some cases the uric acid, urea, and other constituents being diminished, in others increased.

In Dr. Ord's case, urea and uric acid were largely *increased.* In diabetics taking iodide, the same thing occurred (Bouchardat).

On the other hand, Rabuteau, taking daily, for five days, 15 gr. of iodide of potassium, reported marked *diminution* in his urea-excretion—to the extent, some days, of 40 per cent. during the period of experiment, and for nearly a fortnight afterward.

Influence on Nutrition.—From the above discrepant results, it becomes difficult to theorize concerning the action of iodine on nutrition, and further reliable analyses of the excretion under its use are highly desirable. The French physiologists concluded that its influence resembled that of arsenic, *i.e.*, was more of alterative, modifying character, than absorbent and eliminant. My own observations lead me to place more stress upon the latter. Although the medicinal use of iodides in certain disorders may bring about an improved state of the nutrition (Wallace found, for instance, that his syphilitic patients gained flesh under its use); yet, when given continuously to persons of average health, these medicines usually impair nutrition and induce more or less emaciation. This affects the periglandular and fatty tissues rather than the true glandular structures, and it may be connected either with disturbance of digestion, or with certain important physical effects recently traced to iodide of potassium. One of these is the increased rate of circulation produced in capillary tubes when that salt is added to the circulating fluid (Poiseuille), and the other is its dissolving the central substance of starch-granules with great expansion of peripheral layers, so that the grains become twenty-five to thirty times larger than normal (Payem). We may suppose that, introduced into the human economy, the drug both quickens capillary circulation and dissolves glycogenic material.

Pathological Changes.—After death from *iodoform*, fatty degeneration has been found in the liver, kidneys, heart, and voluntary muscles. Binz attributes this to the setting free of iodine in the body.

Idiosyncrasy—Toleration.—There is much difference in the susceptibility of persons to the action of iodine, and we can explain this in no better way than as "idiosyncrasy." Speaking generally, it may be said that pale, thin, languid patients often bear it better than the stout and plethoric, who have a tendency to active head-congestion or stasis of circulation. Such subjects, if rheumatic, are often intolerant of even small doses; so are the sufferers from goître or exophthalmos, or nervous palpitation accompanied with irregular flushing and impaired vaso-motor power.

Climate and soil seem to have some influence, for Coindet's patients in Geneva were much more susceptible than those of Ricord in Paris (*Medico-Chirurgical Review*, ii., 1860). Dr. Lisson concluded that people with fair

skin were more susceptible of the action of this, and all other drugs affecting the skin, than dark subjects, and this may prove some guide. He himself was able, by commencing with small doses, to induce a state of toleration, so that he could take 100 gr. of iodide of potassium without marked effect (*Lancet*, i., 1860). On the other hand, 3-gr. doses have caused severe inflammatory attacks (*Lancet*, ii., 1873, p. 119), and even a less quantity may excite distressing coryza. Bad effects may, however, be often avoided by following Lisson's plan, and inducing tolerance, *e.g.*, I gave a patient with syphilis iodide of potassium in 3-gr. doses thrice daily, but he always suffered from coryza and headache after two or three days; then it was reduced to 1 gr., and the same results followed; then he took ½ gr. thrice daily and had no ill-effects, and the dose was gradually increased, and in a few weeks he was able to take 15 gr. three times daily without any bad symptoms. In one (exceptional) case, iodism setting in after the fourth dose of 3 gr. of iodide of potassium, affected the larynx so intensely as to require tracheotomy (*Lancet*, ii., 1875); and, as already mentioned, Dr. S. Mackenzie traced fatal purpura in an infant to 2½ gr.; but the question may be raised whether the salt was quite pure in such cases. It has also been mentioned that evil results have been attributed to an admixture with iodate of potash, and in such exceptional cases an analysis should be made with reference to this point. *Acute* iodism is generally proportioned to the largeness of the dose; but the *chronic* condition is more readily induced by continued small doses. The iodides of sodium or ammonium are often (not always) better borne than the potassium salt.

Synergists.—The stimulant action of iodine is increased by warmth, alcohol, ozonic ether, the essential oils, etc. Ammonia has been especially found to assist its effect and enable it to be borne, either by chemical combination with it, or by determining free circulation in the skin.

The absorbent effect is remarkably aided by the simultaneous use of mercury, and *vice versâ* (*British Medical Journal*, i., 1875).

Antagonists and Incompatibles.—Cold, quinine, digitalis, the alkaline bromides, and other sedatives to the circulation, moderate or antagonize in part the specific action of iodides; this fact, however, does not prevent their combination for therapeutic purposes. Starch and albuminous substances are the best chemical antidotes to iodine in cases of poisoning.

Carbolic acid and liquor ammoniæ enter into combination with the drug, and remove its brown color, but are said not to lessen its active properties. I have not, however, obtained as good curative results in absorption of tumors from the ammoniated iodine as from the pure drug. Bismuth subnitrate, which is sometimes prescribed with the iodide of potassium, precipitates an insoluble red iodide of bismuth. The organic alkaloids, strychnia, atropia, etc., are precipitated by iodine—according

to Dr. Fuller, 1½ gr. of strychnia by 1 dr. of tincture of iodine; hence, he and other observers have thought them mutually antidotal, but the compounds formed are themselves poisonous (*Medical Times*, i., 1861; *Lancet*, i., 1868), and require removal from the stomach as much as the original poison (*Lancet*, i., 1876). The iodide of starch may be antidotal to sulphides and to caustic alkalies, as stated by Bellini.

Therapeutical Action (External).—Iodine is used (both alone and combined with iodide of potassium or with camphor) in tincture, liniment, and ointment, as a mild stimulant, or strong counter-irritant, or a caustic, according to the strength of the application. It causes pain when applied freely, and in children and delicate tuberculous subjects should be used with special caution.

Strumous Glands.—"Iodine paint" is a common and often a useful application to enlarged and hardened glands in the neck, groin, etc.; but sometimes the constant application of iodine lotion (½ oz. of tincture to ½ pint of water) gives a better result, and is less painful. Mr. F. Jordan recommends painting iodine not *over*, but *round* the enlarged glands, and this is sometimes more advantageous.

If suppuration has occurred, the tincture should be painted over the neighboring thin skin; and if the open sore remain indolent, it should be dressed with iodoform ointment, or with a solution of about 2 dr. of tincture in ½ pint of water, and applied on lint covered with oiled silk. In certain glandular enlargements, the direct injection of iodine tincture acts better and more quickly. Bonalimi (*Medical Record*, 1876), found it more serviceable when the growth was not scrofulous; but Mr. Bradley, writing more recently, recorded a very favorable experience: 1, in true hypertrophy of lymphatic glands; 2, in strumous hypertrophy, before softening has occurred; 3, in hard multiple lymphomata and encapsuled cervical tumor. He used from 5 to 10 min. of tincture, at intervals of four to five days (*Lancet*, ii., 1875). Marston was one of the first to use this method.

The application of iodoform ointment or iodoform collodion deserves trial before resorting to the injection. I have seen some cases as remarkable as the following, recorded by Dr. J. Moleschott. A scrofulous man had a growth of cervical glands the size of a large fist, which was but little affected by iodide and bromide treatment, internal and external, and continued for nearly three years. In November, 1870, collodion 15 parts and iodoform 1 part were ordered to be applied night and morning; in one month the tumor was reduced one-half; in April it had disappeared; six years after it had not recurred. Two children with similar cervical growths, unaffected by ointment of iodide of potassium, were cured in a few weeks by iodoform; and a woman, in whom the growth was of "cartilaginous hardness" and as large as a hen's egg, and of some years' existence, obtained benefit after three months' use of iodoform ointment (1

in 15), and cure within twelve months (*Medical Record*, November 15, 1878).

Enlarged Tonsils.—These are often connected with the strumous diathesis, and iodine tincture is one of the best local applications, though it is an unpleasant one, and sometimes excites much irritation. After some absorption has occurred, I follow its use with the solution of perchloride of iron. In obstinate cases a few drops of iodine tincture have been injected into the substance of the tonsil, with good result.

The internal use of the drug, or of iodides and cod-liver oil, is desirable at the same time.

Bronchocele.—In cases of fibrous and fibro-cystic bronchocele, where calcareous degeneration has not occurred, local applications of iodine should be combined with its internal use. If the part be tender or inflamed, soothing fomentations, or even moderate leeching, may be needed before using iodine; then either the liniment may be painted on once or twice daily for several days, according to the degree of irritation produced, or an iodized collar may be worn (made with iodine sprinkled on wool), or iodoform, or iodide of mercury ointment may be rubbed in as described (*v.* Mercury). I have sometimes been disappointed with the mere external use of iodine in bronchocele, but have had excellent results from its *injection* into fibrous and fibro-cystic cases (25) in which I have used it. In one large fibro-cyst, as to which there was difficulty of diagnosis, no fluid being suspected, 30 min. of the tincture were injected, and considerable diminution of the growth followed; a month afterward 3 oz. of fluid were drawn off, and the cyst injected with 2 dr. of a solution containing 1 part of tincture to 3 of water. The man was highly scrofulous, and the growth of long duration; but, after the inflammatory condition set up by the iodine had subsided, the bronchocele disappeared and gave no further trouble. The only case in which dangerous results occurred was one in which some iodine solution escaped into the cellular tissue, and sloughing of the part followed. Nineteen out of the 25 cases got well, 2 of them having been injected seven times. Lately, Dr. Lücke, of Berne, has reported equally good results in the fibrous form of enlargement. Of 16 cases treated by him, 11 were cured and 4 improved; and Dr. Morell Mackenzie, who at first considered this method inferior to others, records his later experience of it as very favorable. He obtained unexpected cures in fibrous and adenoid cases from the weekly or biweekly injection of 30 drops of tincture (*Medical Times*, i., 1872, and *British Medical Journal*, ii., 1873). Dr. Luton speaks well of similar injections of iodic acid—1 part to 5 of water; he uses about ½ dr. at one time (*Lancet*, ii., 1873, p. 457). (*v.* Internal Use.)

Orchitis.—If hardness and swelling of the testicle remain after subsidence of the acute stage of this malady, iodine lotion or ointment, with strapping, will prove effective. Alvarez has reported exceptionally good

results from iodoform ointment (1 to 2 gr. to 30 of simple ointment) in blennorrhagic orchitis. It is said to relieve pain in one to two hours, to shorten the duration of the malady and of subsequent induration, and "exert a resolvent action," without any constitutional disturbance like that of mercury (*Medical Record*, 1877).

Prostatitis.—In subacute and chronic enlargement affecting the prostate gland, I have seen much advantage from iodine, and still more from iodiform ointment, though Sir H. Thompson, in his treatise, does not speak favorably of the former, nor does he mention the latter.

In cases of chronic enlargement, Heine states that he has injected the tincture into the substance of the gland, with successful results (*Medico-Chirurgical Review*, i., 1873).

Mammary Growths.—Congestions and localized hardness and obstruction of mammary ducts are amenable to iodine frictions, but the skin of the breast is very sensitive and easily irritated. I can recommend a weak solution of iodoform (1 in 15 to 30) for many of these mammary growths. In 1871 I ordered it for a lady with a large, suspicious-looking tumor, which was to have been removed the following week under the advice of an eminent surgeon. The growth quickly diminished under the iodoform, and the lady is now (1880) quite well. This is only one of many similar instances which have come under my own observation.

Pleuritis—Phthisis.—The external use of iodine will frequently relieve subacute pleuritic pain and the "flying" chest-pains which are common in phthisis. Iodoformed collodion (1 part in 15 to 20) is said to act especially well in such cases, and to exert the further effect of lowering the body-temperature (*British Medical Journal*, i., 1879). In chronic pleuritis with effusion, iodine liniment or ointment has some power to promote absorption; and in phthisis and chronic bronchitis, painting it over the front part of the chest serves to impregnate the air which is breathed, and modifies expectoration and the state of the bronchial membrane. Inhalation of iodine may also be practised, and a few grains may be left on a plate in the sick-room with advantage. Fetid organic odors from the breath, etc., are lessened by it (Richardson: *Social Science Review*, July, 1864). Iodine, 10 gr., dissolved in 1 oz. amyl hydride, makes a good inhalation (*Medical Times*, ii., 1871).

Diphtheria—Croup.—I have found an iodized spray or inhalation often useful in these maladies. Dr. W. Curran gives a good formula, containing 4 gr. each of iodine and iodide of potassium in ½ oz. alcohol and 4 oz. water. Of this one to four teaspoonfuls may be added to a pint of boiling vinegar or water, and the vapor inhaled every two hours for five to ten minutes.

Menzel has injected a few drops of tinct. iodi into the soft palate and tonsils in diphtheria, and apparently with success (*Medical Times*, ii., 1873).

Chronic Peritonitis.—In this malady, especially when occurring in strumous subjects, and accompanied with enlarged mesenteric glands, the external use of iodine in the form of ointment, liniment, or compress, should be conjoined with internal treatment.

Chronic Visceral Congestion.—In chronic congestion of the liver and spleen, the external application of iodine is often useful.

Uterine Congestion, etc.—In congestive enlargement of the uterus, with some induration of the cervix connected with sub-involution or chronic inflammation, benefit may be derived from iodine locally applied. Tepid injections containing 1 to 2 dr. of the tincture in a pint of water, and also iodized hip-baths, are useful. Dr. Greenhalgh prepares an "iodized cotton" by saturating 8 oz. of cotton in the same quantity of glycerin, containing 1 oz. of pure iodine and 2 oz. iodide of potassium, and keeps a pledget of this pressed for some hours against the cervix, withdrawing it when necessary by a thread secured to it. Dr. Graily Hewitt applies the tincture directly to the inflamed part, and recommends this treatment especially for patients of sluggish habit and scrofulous diathesis. My own experience of this treatment in similar cases is favorable. Dr. James Bennett recommends direct injection of an iodized solution in chronic cervical metritis (*Dublin Medical Journal*, October, 1878). In cases of granular erosion and ulceration, the iodide of silver, prepared extempore as recommended by Dr. Wright, by adding a few drops of iodine tincture to some nitrate of silver solution, may be used with much advantage ("Diseases of Women"). In amenorrhœa dependent upon torpor of the uterine system, local applications of iodine are useful.

Menorrhagia.—In persistent cases Dr. Savage, and also Dr. Routh, have used intra-uterine injections of iodine (*Lancet*, 1851; *Medical Times*, i., 1860), but this treatment involves too much risk for ordinary use. In chronic uterine leucorrhœa Dr. G. Murray applies the remedy by means of a sound, which is safer than injection (*Lancet*, 1866).

Injection of Cysts—Hydrocele.—The injection of iodine in cases of hydrocele gives better results than any other remedy. Port wine and tincture of iron are both very inferior to it. The serous fluid should first be evacuated thoroughly, and then 1 to 4 dr. of iodine tincture injected (according to the size of the cyst). Sometimes inflammatory reaction occurs, and lasts two to six weeks, but the ultimate result is usually good. I have seen one case of fifteen years' duration, where the scrotum hung nearly to the knees, and was supported by a sling round the neck; after puncturing and evacuating, 6 oz. of iodine tincture were injected: the physiological effects were strongly developed, but complete cure followed.

I believe that Sir Ranald Martin introduced this method of treatment, but he diluted the tincture with two parts of water.

Mr. Furneaux Jordan has recently written to advocate the use of two

or three threads soaked in the tincture and drawn through the hydrocèle, to act like a seton. This succeeds in some cases (*Lancet*, i., 1876).

Spina Bifida.—I have not myself had much experience recently in the use of iodine in this deformity, and what I had in former years was not favorable; but the results of Dr. Brainard, Dr. Morton of Glasgow, and others, have placed the operation on a new basis. The latter surgeon, in 1876, reported fourteen cases, eleven of which were successful; and in the majority not only was the sac obliterated, but improvement as to paralysis and general health occurred. The cases were not simply those in which connection with the spinal canal was naturally obliterated, and which might fairly be expected to recover, but included some of much more serious nature. The solution used ("Morton's solution") was—"iodine, 10 gr., iodide of potassium, 30 gr., glycerin, 1 oz.," and of this ½ to 1 dr. was injected after removal of more or less fluid, according to the case (*Lancet*, ii., 1876).

Dr. G. W. Thompson records an instructive illustration, in which the tumor over the sacral region was twelve inches in circumference ten days after birth; it was attached by a peduncle and communicated with the spinal canal. After tapping and removing about 2 oz. of fluid, 25 min. of Morton's solution were injected and the aperture sealed. There was much shock, and brandy was given freely. Gradual improvement, however, took place, and six months afterward only a mass of thickened skin remained (*British Medical Journal*, ii., 1878).

My colleague, Mr. Pearce Gould, has recorded an interesting case of recovery under similar treatment. The child, aged eighteen months, had a sessile tumor as large as a cricket-ball, situated over the last lumbar and sacral vertebræ, and communicating with the spinal canal. At the first operation 6 dr. of fluid were drawn off, and ½ dr. of Morton's solution injected; at the second operation 1 oz. was removed and 1 dr. injected; at a third, 2½ oz. removed and 2 dr. injected. There was neither shock nor convulsion; improvement set in on the ninth day after the last operation, and ultimately only a flat mass of dense tissue remained; there was no paralysis ("Clinical Society's Transactions," vol. xi.).

Of two other cases treated by Mr. Gould after Morton's method, one died of purulent spinal meningitis a few days after the second injection; the other left the hospital and was not seen again.

Hydrarthrosis.—In extensive chronic serous effusion in the knee-joint, injection of iodine has been successfully practised by Velpeau and others. One part of iodine, 2 of iodide of potassium, and 8 of water, are injected in about the same quantity as is withdrawn by aspiration; air should be carefully excluded from the wound. Mr. C. Macnamara has injected 1 oz. of the pure tincture with quite satisfactory result ("Lectures on Diseases of Bones and Joints," 1881).

In less severe cases of effusion, in bursal effusions (housemaid's

knee), and in rheumatic and gouty joints, the external application of iodoform, or iodine paint, promotes absorption, and should be tried before puncture. Dr. Fuller recommended a lotion containing ½ oz. of tinct. iod. co. in 6 oz. each of glycerin and water, and applied on lint covered with flannel; frictions and douches should be combined with this treatment (*Lancet*, i., 1863).

Pleuritic Effusion.—The external use of iodine, combined with pressure, aids in the absorption of such effusions, and some surgeons have, in chronic cases, injected a weak iodine solution (4 to 5 gr. to the pint) into the pleural cavity, and with ultimate success. It seems to be, however, an operation of unusual risk, and one which has been followed, more than once, by death from inflammatory reaction, embolism, or shock (*v.* Empyema).

In *Ascites* of chronic character, M. Boinet injected iodine, in the first instance by mistake, thinking the case ovarian; but, after a very serious attack of peritonitis, the patient at length recovered ("Iodothérapie," 1855). Leriche, Dieulafoy, and some few other surgeons have recorded similar cases, and remark that the ascitic fluid should not be all evacuated previous to injection, so that moderate dilution of the iodine may be insured. Dr. Ford (U. S.), has recently reported two cases of ascites cured by iodine injection, so that the operation is by no means obsolete. One of his cases "was connected with renal mischief," the other "followed on cessation of the menses." After tapping, he injected 2 oz. of tinct. iodi with an equal quantity of water (*Practitioner*, i., 1877).

The cases alluded to are not very clearly described by their narrators, but we must recognize that those suited for this method of treatment can only be of certain kinds; for instance, such as are dependent on chronic peritonitis, or simple anomalies of secretion, or perhaps on hepatic disorder, but not cases of ascites connected with cardiac or advanced renal disease, or anæmia.

Empyema.—In chronic cases, provided a free opening is secured, an iodine injection (1 to 2 dr. of tr. in the pint) is sometimes serviceable, both to disinfect and to stimulate healthier secretion and contraction of the cavity, and many patients have, doubtless, recovered under its use. Dr. Dickinson speaks of it as better than any other treatment in his experience (*British Medical Journal*, 1876). On the other hand, I have myself known it excite much undue irritation, both local and systemic. In some cases, sudden or nearly sudden death has followed the injection of iodine solutions into the pleural cavity; but we cannot reasonably attribute the result to iodine, because in the very same cases iodine had been previously used without harm, and besides, sudden death has followed, in a similar manner, the injection of warm water, of carbolic acid lotion, etc. The effect may have been connected, rather, with mechanical conditions, such as insufficient freedom of exit, too great pressure

of fluid, etc., or else with special cardiac conditions of feebleness, dilatation, etc., but certainly, I am strongly of opinion that injections into the pleural cavity are never without some risk, and can seldom be practised safely; they should be discontinued in favor of free drainage with strict antiseptic precautions.

A little of the solid iodine, placed in perforated chip-boxes in or near the bed, forms a good disinfectant in cases of foul wounds, discharges, etc.

Pericardial Effusion.—I have treated several severe cases of this condition by iodine injections; for instance: 1. G. H., aged thirty-seven, had in youth two attacks of rheumatic fever with endocarditis of aortic valves; when otherwise robust, a third attack came on in August, 1876. In November, when I first saw him, there was extensive pericardial effusion, with visible bulging and fluctuation; cardiac dulness extended beyond the right of the lower sternum, and upward as high as the second rib; the heart-sounds were feeble and indistinct, and the respiration impeded; there was a short, dry cough, and extreme orthopnœa, so that life was in imminent danger. I drew out 3 oz. of fluid, and injected 10 min. of iodine tincture; relief was experienced, and I repeated the operation in forty-eight hours. After this the man gradually recovered, though eight months afterward he died suddenly from his aortic disease. 2. In another man, aged twenty-three, also suffering from extensive pericardial effusion, with intense dyspnœa and other urgent symptoms, 2 to 3 oz. of fluid were drawn off by aspiration (with much relief), and 10 min. of iodine tincture injected. Thirty hours afterward, 10 min. more were injected; no symptoms of iodism appeared, and the patient made a good recovery. In both cases, 4 to 6 gr. of iodide of potassium were taken in bark thrice daily, before and after the operation.

Abdominal Cysts.—The following case, which occurred in my practice some years ago, will illustrate some of the risks and the possibilities of treating large cysts by strong iodine injections. A gentleman, aged seventy, had an enlargement of the abdomen, which was obscure in its nature, and variously diagnosed as dependent on liquid effusion or a solid growth from the under surface of the liver. Attacked one day with rigors and sudden, violent pain, he became jaundiced and collapsed, and when seen by me was semicomatose and apparently dying. Some obscure fluctuation being detected in the enlargement, a trocar was inserted, and 21 to 23 pints of thick, grumous fluid, with some pus, were drawn off; this was examined by special microscopists without detection of any hydatids or hooklets. Three weeks afterward, 16 pints of fluid were drawn off, and 16 oz. of pure tincture of iodine (British Pharmacopœia) injected, allowed to remain for twenty minutes in the sac, and then some of it to escape.

Severe effects soon followed the injection: salivation, soreness of

mouth and throat, sickness, eructations, headache, giddiness, tinnitus aurium, museæ volitantes, etc., accompanied by palpitation and pyrexia; the pulse was 140, weak and irregular, the temperature 101.8° F. Epistaxis occurred twice during the first thirty-six hours; tightness across the chest and pain at the epigastrium were complained of, and frequent thin, watery stools were passed; the general condition was one of extreme nervousness, prostration, and unrest.

On the second and third days the temperature, which was highest in the afternoon, varied from 101° to 104° F., and the pulse from 110 to 140. Pains in the limbs and in the loins set in, and were felt also in the long bones, which presented all the evidence of periostitis; synovial effusion distended the left knee-joint; the urine, which was at first pale and profuse, became scanty and bloody, and both it and the saliva contained large quantities of iodine; the salivary glands were painful and swollen, and the palate and fauces sore and inflamed; there was constant short, dry cough, with more or less aphonia.

All these symptoms continued to increase until the end of the fourth day, when an eruption, somewhat like measles, appeared, with apparent relief to many of the urgent symptoms. By the fifth day the periostitis had considerably subsided, and by the ninth, most of the other symptoms had disappeared. Iodine was, however, excreted by the urine for about sixteen days, and albumen for twenty-five days; during the whole time nourishment was taken well. After the severe attack convalescence progressed favorably, and the patient lived for two years afterward, and died from the effects of cholesterin calculus.

Ovarian Cysts.—When the cyst is unilocular and no acute symptoms present nor active growth going on, then the injection of iodine may in some instances prove useful, although the radical operation of removing the diseased ovary has now such an average success that the less certain method of injection is seldom employed. M. Boinet records 45 cases, treated by tapping and injecting equal parts of iodine tincture and water, allowing this to remain for a few minutes while the abdomen was gently manipulated, then to escape; 31 out of these cases are said to have been successful, while 9 ended fatally. This is a much higher mortality than after ovariotomy.

Velpeau, Simpson, and Spencer Wells have also obtained, on the whole, favorable results with the same method (*Medical Times*, ii., 1860), but Dr. Tyler Smith succeeded in only 2 out of 10 cases in which he employed it, and of 6 patients treated by Schuh, only 1 was cured and 1 relieved. My own experience of injection in ovarian dropsy, though not large, is rather favorable. In one case, now nineteen years ago, I withdrew a pint of fluid from a large cyst, and injected 4 oz. of iodine tincture, and after repeating this three times, absorption ultimately took place, and the lady, now living, has had no further inconvenience. In another

similar case in which I drew off a pint of fluid, and injected 2 to 3 oz. of iodine tincture, severe physiological effects followed, and continued for ten days; but the patient soon rallied, and three months afterward 4 oz. more were injected, and absorption of the cystic fluid rapidly took place. This was in 1864, and at the present time there remains only a growth the size of an orange, which gives rise to no annoyance.

In both cases the cysts were judged to be unilocular, and were of some years' duration, but the operation, though favorable in result, required repetition, and produced for a time troublesome symptoms. It is clearly not one to be adopted without much consideration, and only for cases such as those described, where the patients would not submit to removal of the ovary. Sometimes a fatal issue has followed directly from iodine injection, as in the often-quoted case of Dr. E. Rose. He injected into an ovarian cyst 5 oz. of iodine tincture containing 1 dr. of iodide of potassium, and severe symptoms of iodism and collapse immediately set in, with vomiting and cyanosis; scanty, dark urine, containing iodine, was excreted; three days afterward the cutaneous capillaries dilated, the face flushed, maculæ appeared on the skin, and hemorrhage occurred from the lungs and uterus.

On the eighth day, most of the urgent symptoms had disappeared, but the urine still contained iodine and albumen; on the tenth day, death occurred suddenly from cardiac failure (Nothnagel).

Ranula.—It has been recommended to inject the sac of a ranula with iodine after emptying its contents; I have made numerous trials of this plan, but have abandoned it as unsatisfactory.

I used it three times in one case, but with no other result than to cause much irritation; cure was ultimately obtained by dilating the duct aperture with laminaria.

Abscess Cavities.—The injection of iodine has been resorted to, and sometimes with success, for the purpose of disinfecting such cavities and controlling the secretion of pus.

Boinet gives the history of a chronic abscess occupying the whole right iliac fossa; it followed a bubo, and discharged profusely by a fistulous tract. After many months of unsuccessful treatment by injections, ointments, nitrate of mercury, potash, compression, etc., he injected a solution of iodine (2 dr. of tincture in 4 oz. of water) to the bottom of the cavity through a catheter; much pain followed, and afterward severe febrile reaction, but in about a fortnight radical cure was obtained (Iodothérapie). Such successful results cannot be always depended upon, and, in fact, I have known injury from this mode of treatment in many such cases; for instance, in one case of psoas abscess, an injection containing 1 dr. of tincture in 3 oz. of water was practised three times in a fortnight, but considerable irritation and increase of hectic was set up without subsequent improvement; after an interval of four months it was repeated

(1 dr. in 4 oz.), but with the same result, and the patient died shortly afterward; vertebral caries was found, but only slight in amount.

In another similar psoas abscess, where the malady was not recognized until an opening in the groin had nearly occurred, iodine was injected, and induced much hectic and aggravation of symptoms; no improvement could be traced to repeated injections, but the patient is still living.

In smaller abscesses I have found the injection of iodine beneficial; it offers less risk than in large psoas abscess, and is more likely to succeed. Mr. Stirton found it answer well in a chronic scrofulous abscess of the groin—he used 2 gr. to 1 oz. of water (*Medical Times*, ii., 1870).

Fistula.—In some cases, iodine injection is said to have answered well. Lachrymal fistula has been cured by it (*Lancet*, i., 1874), also congenital branchial fistula (*Medical Record*, 1879). In rectal fistula an ethereal solution has been of service (*Lancet*, ii., 1872), but should not be allowed to remain in the bowel, as it may cause severe pain (*Medical Times*, i., 1860). A good, colorless disinfectant and cleansing lotion for such cases is made with tinct. iodi ʒ iss., glycerini ℥ ij., sol. calcis chlorin., ʒ vi.; use ½ oz. to 6 or 8 oz. of water (Dr. Boggs). Mr. Stirton has related a case of rectal fistula in which the ordinary operation had failed several times, but succeeded when iodine injection was commenced immediately after it. In my own experience, I have never known iodine by itself cure anal fistula, and should always recommend an operation in preference to injections of any kind. Iodized injections are, however, often useful in stimulating old atonic sinuses in the neighborhood of joints, etc.

Fissure of Anus—Hæmorrhoids.—An ointment or suppository containing iodoform—5 to 15 gr. in the ounce—relieves the pain in defecation connected with these maladies.

Ulceration.—When the skin is broken and there is purulent discharge, as in severe burns or chilblains, or after wounds or injuries, iodoform ointment or lotions of iodine will disinfect the pus, relieve pain, and promote healing. I agree with M. Lailler (Hôpital St. Louis), who states that the former preparation acts as a local anæsthetic, and favors cicatrization in a remarkable degree, "it modifies ulcers of every variety," but should not be used while they are acutely inflamed; this stage being passed, the surface should be carefully cleansed and dried, and then either the finely powdered crystals, or a solution in sulphuric ether (1 part to 8 or 10) should be pencilled over and covered with lint; the ether evaporates, leaving a thin film of iodoform (*Medical Record*, February, 1878). From observations in eczematous cases, Mr. Squire concludes that it is best used during the puriform stage, and ceases to be suitable when the discharge becomes purely serous—he prefers a glycerole (*British Medical Journal*, i., 1881). Dr. Richardson speaks highly of a solution of iodine —20 gr. in amyl hydride 1 oz.—for painting over suppurating wounds;

this also leaves a thin protective film. Or the vapor of iodine may be applied by putting a few grains of the element between a fold of lint, which is placed over the wound and covered with cerate and oiled silk.

In ulceration about the mouth and tonsils, and in the severe form called "cancrum oris," touching with strong iodine solution is often curative.

Onychia.—The duration of this very painful and obstinate form of suppuration may be much shortened by iodoform ointment, of strength 1 dr. to 1 oz. (*Medical Times*, ii., 1872; *Medical Record*, 1878). I have used it frequently, with excellent results.

Gingivitis—"*Tartar.*"—The local application of tincture of iodine will usually cure inflammation, sponginess, or tenderness of the gums, and will soften deposits of "tartar," so that they may be readily removed with the brush.

Ulceration of Tongue—Gumma.—In obstinate syphilitic affections of this description, with ragged, thickened epithelium, deep fissures, and severe pain, Mr. Berkeley Hill has found iodoform very useful, applied locally to the part and given internally.

Syphilitic Ulceration of Throat.—Iodine liniment or iodoform externally, and the tincture or iodide of potassium internally, are very serviceable in this condition.

Chancre—Bubo.—M. Lailler, in a large experience at the Hôpital Lourcine, found iodoform a most useful dressing for all forms of venereal ulceration (cf. *Lancet*, ii., 1878). Mr. Berkeley Hill adopts it as an almost invariable treatment of "specific sores;" also Profeta, Sheen, and others (*Medical Times*, i., 1875; *Practitioner*, i., 1879), and Dr. W. Cottle has observed chancres heal more rapidly under this remedy than under many others (*British Medical Journal*, i., 1878).

If secretion is abundant, *the sore should be cleansed* and dressed twice daily with the finely powdered crystals, or an ointment containing iodoform. Smarting may be caused at first, but this and the pain of the disorder soon subside, and healing often takes place in a week or ten days. The unpleasant odor of iodoform is, however, a drawback to its use, and its results are not always so satisfactory as described above.

Gonorrhœa.—Gonorrhœal attacks in females can sometimes be cut short by one or two paintings of the vagina, cervix uteri, labia, and urethral canal with strong tincture of iodine, after first cleansing away the discharge. The pain lasts for some hours, but the result usually is good.

Purulent Ophthalmia.—M. Boinet relates a severe case of double ophthalmia and scrofulous catarrh, which had lasted for thirteen months when admitted into the St. Louis Hospital, but was relieved; and, in a few weeks, cured by the constant employment of an iodine lotion and nasal

injection. I began to use this treatment in such cases many years ago, and often had excellent results.

Keratitis—Photophobia.—In ulceration about the cornea, and in granular lids, iodine tincture is a good application; and the liniment, painted round the eye, relieves the photophobia so frequent in scrofulous children.

Otorrhœa—Aural Polypus.—Dr. Cassells (Glasgow) states that iodoform is very useful in these conditions, and in granulation from the membrana tympani, and caries affecting the meatus.

Catarrh.—The vapor given off by powdered camphor sprinkled with tinct. iodi has been found effective for arresting coryza (*Medical Times*, i., 1874); and inhaling from pure iodine, or carbolate of iodine, is also commended. The latter has been introduced as a patent remedy.

Ozæna.—In this obstinate disorder, and in various cases of post-nasal ulceration and discharge, the local use of iodoform has been much commended by specialists. Mr. Woakes, however, found an ethereal solution very painful, and obtained good results with pledgets of iodoformed wool *British Medical Journal*, i., 1878).

Erysipelas.—Several authors concur in stating that the local use of iodine tincture will relieve this inflammation.

Lanyon relates a case of idiopathic erysipelas, affecting the right side of the face and rapidly extending. The tincture was painted over and beyond the inflamed part; within four hours pain was relieved and sleep obtained; the malady did not advance, and, after another application, next day, convalescence set in.

Boinet records two cases of "traumatic" erysipelas—one connected with suppurating wounds in the perineum, and affecting the right thigh, the other starting from a varicose ulcer, and affecting the whole leg. Thorough application of iodine tincture, once daily for three days, rendered the wounds healthy, and controlled the inflammation and swelling. Dr. Davies is another advocate for the same remedy, used rather stronger (40 gr. iodine to 1 oz. alcohol).

Bartholow and others have not been so well satisfied with it, and care must be taken not to cause undue irritation by its use.

Burns—Chilblains.—In burns of the first degree and unbroken chilblains the pain, itching, and irritation may be relieved by iodine tincture, liniment, or ointment.

Lupus.—In erythematous lupus, and in early stages of the tubercular and markedly strumous forms, strong iodine paint is sometimes useful; equal parts of pure iodine and iodide of potassium, in two parts glycerin, may be used about twice weekly; this excites "substitutive irritation," and exerts some absorptive power, though I have not myself seen curative results from it. The plain tincture of iodine relieves the congested livid condition of the neighboring skin if painted over it. Iodoform deserves a very careful trial (*v.* p. 86).

Acne—Sycosis.—Simpson recommended for indolent "menstrual" acne, a decolorized iodine paint made by mixing tinct. iodin. co. 1 part, with liq. ammoniæ 2 parts, to stand forty-eight hours (*Medical Times*, i., 1861). I have not found this preparation so effective as ordinary iodine when applied to glands, etc., and for acne there are several better remedies. The ointment of iodide of mercury is more valuable in acne rosacea, and that of iodide of sulphur in indolent acne and sycosis.

Psoriasis.—In patches of obstinate chronic psoriasis the ointment of green iodide of mercury, or of iodide of sulphur, is very useful. I can speak well especially of the former, made in the proportion of 1 part to 8 of simple ointment. The effects are often more rapid and decided than those of tar ointment. Occasional alkaline or vapor baths should be used during the treatment.

Pityriasis Capitis—Alopecia.—In branny, scaly conditions of the hairy scalp, and in partial falling off of the hair from debility, painting with iodine tincture acts as a useful local stimulant. It should be combined with other treatment, such as soap-frictions.

Pruritus.—In many varieties of this disorder—pruritus pudendi, pruritus senilis—iodine tincture locally applied often gives much relief.

In a case of hyperæsthesia of the vulva, without local lesion, but with severe "dyspareunia," powdering with iodoform rendered the parts quite insensitive to pain (Tanner). A tampon of iodoform had good results in another case.

Tinea Tonsurans.—In simple recent cases of ringworm affecting the body or the scalp, a few applications of iodine tincture or liniment may suffice to cure, but they seldom succeed in an aggravated case. The preparation introduced by Mr. Coster ("Coster's paste") is, however, more powerful. It is a solution of 1 part of pure iodine in 4 of "colorless oil of tar," and requires to be mixed carefully, for heat is developed during the combination; the resulting thick, dark-colored liquid should be thoroughly painted over the affected part and allowed to form a crust, which may remain for seven to ten days. One or two such applications will often cure, but to say that they do not cause pain is a mistake. The pain has seemed to me about equal to that caused by the iodine liniment, which is sometimes severe.

Therapeutical Action (Internal).—Iodine and the iodides have a similar action; the former is more stimulant to the general system, but more irritant to the gastric mucous membrane. It is probably better adapted for slowly modifying the general constitutional state, as, for instance, in struma; while the alkaline iodides, being more quickly passed out of the system, act better where some foreign material needs elimination, *e.g.*, in syphilis, lead-poisoning, or rheumatism. Practically, however, the much less irritant effects of the alkaline compounds indicate,

independently of other considerations, their employment in the majority of cases for which iodine in any form is needed.

Metallic Poisoning.—Melsens found that every mercurial compound was soluble in an alkaline or neutral solution of iodide of potassium, and that corrosive sublimate, for instance, if fixed in a muscle, tendon, etc., could be dissolved out of the organic tissue by soaking it in such iodide solution. Also, that even metallic lead was, to some extent, soluble in the same medium, with formation of a double iodide of lead and potassium (*Medico-Chirurgical Review*, i., 1853). Hence, he argued that in cases of mercurial or lead-poisoning, with salivation, tremor, colic, palsy, etc., iodides introduced into the blood could form soluble compounds with metal deposited in the tissues, and enable this to be taken up by the absorbents and passed out by the kidneys and other channels of excretion. Support has been given to this argument by the fact that an insoluble salt of mercury or lead may be given to animals without evident effect until after the administration of an iodide, when the recognized symptoms of poisoning appear. Further, we know, clinically, that sometimes in metallic cachexia, when active symptoms are no longer present, and the poisons are not detectable in the secretions, if an iodide be given, acute mercurial or lead-action may be developed, and the foreign substances may be found in the urine, etc.

Only *chronic* conditions of illness, such as palsy or cachexia, may be present when the iodide is commenced, but in the course of a few days *acute* symptoms, such as colic or salivation, may be reproduced until elimination is complete. But however the theory on the subject may stand, there can be no doubt that iodides often act well in plumbism, and, although I have not always succeeded with them, I have had some good results. The case of M. Faure, recorded by himself, is a good illustration of their value: engaged in white-lead manufacture, he suffered severely from the ordinary symptoms of plumbism, and cured himself with iodide of potassium. He remarks that he could tolerate the drug better when he took it *before*, than *with* food, which he attributed to the "fasting stomach being coated with mucus" (*Medical Record*, 1876).

Dr. H. Thompson has given the details of a case of plumbism, in which iodide of potassium, on three or four occasions, led to relapse of colic at the same time that iodism was developed, and these attacks were always followed by improvement in the paralyzed extensor muscles, as if some of the metallic poison had been eliminated, though there is not a record of its detection in the secretions (*British Medical Journal*, i., 1871). Jacobs thinks the best results are obtained with the iodide in conjunction with emetic and purgative treatment (*Medical Record*, 1877).

Syphilis.—It is probable that iodine acts in this disease, much as it does in metallic poisoning, by assisting the elimination of a morbid material. It has been maintained, indeed, by Dr. Basham and others, that

its influence is best seen in cases which have been previously treated by mercury; and Dr. Budd and Dr. Garrod have given instances in which mercurial influence was dormant until excited by the administration of iodides, when profuse salivation occurred, and recovery ensued. But there can now be no question that the drug has curative powers of its own, independent of mercurial action; they are evidenced especially in the later, or tertiary stages of constitutional syphilis, when either the mucous membranes are affected, as in deep ulceration of the fauces, or the bones are attacked with periostitis or nodes, or the skin suffers with rupial or lupoid eruption, or the brain-membranes are thickened, or gummatous deposits are formed in any of the viscera. In such conditions it usually acts far better than mercury, although this latter drug is more advisable in some *eye-inflammations*, such as iritis; and again, in a certain proportion of undefined syphilitic cases, an iodide of mercury will give better results than either medicine alone.

By causing the absorption of deposits and thickenings in various parts of the body, iodides cure, at the same time, many secondary and dependent symptoms, such as nocturnal pains, neuralgia, paralysis, dulness of sense or intellect, and convulsive paroxysms. The dose of iodide of potash is a matter of much importance, and need be limited only by the susceptibility or idiosyncrasy of the patient, and the progress of the disease; it may vary from 1 or 2 gr. up to 60 gr., two or three times daily, and the best results have sometimes been obtained from heroic doses, when ordinary ones have failed.

Elliotson gave 30 to 60 gr., or more, for a dose (*Lancet*, i., 1832), and Ricord commonly prescribed the same amount. Sir A. Cooper, Drysdale, Pollock, and others, have given instances of the value of such quantities (*British Medical Journal* and *Lancet*, 1867–68); and more recently Dr. Buzzard has pointed out the importance of large doses, especially in syphilitic affections of the nervous system (*Lancet*, i., 1873).

In *hereditary syphilis* I prefer mercurial treatment, though infants generally bear iodides well.

Mr. Berkeley Hill has stated that the iodide of ammonium or of sodium will sometimes cure when the potassium salt has failed, and this fact should be remembered in practice (*British Medical Journal*, ii., 1871).

Rheumatism.—Dr. Graves was one of the first to indicate the value of iodide of potassium in rheumatism, and it is now well established. I connect its efficient anti-rheumatic action mainly with an eliminant action through the kidneys, and to promote this, recommend it to be largely diluted and combined with bicarbonate of potash in acute cases. To prevent irritation of the stomach, the medicine may be given in an effervescent form. Sometimes, if the patient be feeble, and the urine abundant and of low specific gravity, the iodide may be combined with hydrochloric acid and quinine, as recommended by Dr. Southey. When effusion

has occurred into the pericardium or the joints, tincture of iodine or iodides are certainly indicated. In muscular rheumatism they are useful, especially in those cases where the pains are made worse by warmth. This is one character of periosteal and syphilitic pain, and possibly some of the good results obtained from iodide of potassium in cases of chronic painful joints, sciatica, and lumbago, may be explained by its removing a latent specific or mercurial, or other metallic taint. In cases of chronic rheumatism, small doses of iodide, continued for a long time, often act exceedingly well; but some patients are very sensitive to its physiological action, and need special care to secure its toleration (*v.* pp. 68, 94).

Gout.—In chronic forms of gout the iodide will often relieve, as remarked by Mr. Spencer Wells, who recommends 1 or 2 gr. thrice daily, well diluted with water or seltzer water. In some cases the tincture acts better.

Chronic Rheumatic Arthritis.—In this condition, often considered incurable, I have known the tincture of iodine prove very useful when given in 3-min. doses thrice daily, and applied locally; in others the good effect has been remarkable when given at the same intervals, but in doses of 10 to 20 min.

Gouty Psoriasis.—In this malady the iodide deserves trial. In one case of the "inveterate" form, and of twenty years' duration, recovery followed the use of 10 to 30-gr. doses. There was no history of syphilis—only some suspicion of it from the copper color of the rash (*Lancet*, i., 1871).

Ague—Intermittents.—Iodide of potassium is stated to have proved very efficacious in intermittent fever (*American Journal*, April, 1867; *Medical Times*, ii., 1872). The tincture of iodine is the "Elixir de Willebrand" used on the Continent in doses of 10 to 15 min., and, it is said, with success (*British Medical Journal*, ii., 1874).

Paralysis.—Cases of this disorder recorded as cured by the use of iodides were probably dependent on syphilitic deposits, or inflammatory or rheumatic effusions pressing upon nerve-trunks. In such cases it is certainly possible for these remedies to produce the necessary absorption and consequent cure.

Muscular Paralysis, acute and general in character, has sometimes yielded to the iodides in a remarkable manner, as instanced in a case of Dr. Murchison's (*Lancet*, ii., 1867). The man, aged twenty-six, had gradual loss of power and wasting first of the left, then of the right limbs, and then of respiratory muscles, and apparently progressive paralysis, with moderate pain, and no cerebral symptoms; he got worse under iron, arsenic, and galvanism, but improved markedly under iodide. Another case is given in *Medical Times*, ii., 1863; both were connected, probably, with a spinal meningitis.

Cerebral Palsy is not usually treated by iodides, but Dr. Sieveking

considers that advantage may be derived from their eliminant action after acute symptoms have subsided (*Medical Times*, i., 1857). They may act usefully by regulating and equalizing the circulation, as well as by aiding absorption of any inflammatory products.

Neuralgia.—In such cases, if of a syphilitic or rheumatic origin, iodine is useful; and in rheumatic sciatica the combination of iodide of potash with vinum colchici is often very effective.

Chorea.—Manson affirms that he has cured seventy-two cases of chorea by giving iodide of potash. Bardsley and Gibney make similar statements, but many of these cases would probably have come to a natural termination after six or seven weeks' rest, even without iodine. We are still much in the dark as regards the nature of chorea, and from a rational point of view iodine can only be recommended for it as likely to influence a scrofulous, rheumatic, or syphilitic taint.

Epilepsy.—Magendie stated that he had cured this disease by iodide of potash, and Franklin gave to a boy, aged eight years, as much as 180 to 300 drops of iodine tincture, and curiously enough the boy bore it well and was cured (Köhler).

It seems to me that the remedy can only serve in such cases if there be a syphilitic or rheumatic origin.

Struma—Rachitis.—In the different manifestations of these constitutional states, such as enlarged glands, tumid abdomen, indolent ulceration, ophthalmia, etc., preparations of iodine, and especially the tincture, are of proved value. But though they lead to disintegration of morbid deposit, they do not appear to assist renovation of tissue, and for permanent good results require to be supplemented by good food and hygiene. Hence, also, the combination with iron—iodide of iron—is an excellent form, and the conjoint use of cod-liver oil is very desirable. These remedies are invaluable in rachitis especially, and are usually well borne by delicate children when alkaline iodides are not. Simon, indeed, concludes that the latter ought not to be given at all under two years of age (*Medical Record*, 1876), and even the iodide of iron sometimes excites gastric and renal irritation, especially in some delicate children with fair skin, red hair, and enlarged throat-glands, so that it is desirable to commence its use in small doses.

I have been accustomed to give 1 to 3 min. doses of iodine tincture well diluted, and continued for a considerable time, in cases of struma, and can recommend this form of medication. The iodide of ammonium is said sometimes to have exceptional value.

Lupus.—I have mentioned the external use of iodine in the treatment of this disease (*v.* p. 81), and there is some evidence in favor of its internal employment. Thus, Mr. Gay records cases of lupus affecting the face—in one man for seven years, in a woman for twenty years—which yet got well under ½-dr. doses of iodide of potassium (*Medical Times*, ii.,

1871). There was no obtainable history or distinct evidence of syphilis, though one cannot but suspect a syphilitic taint in such cases. I have never known iodides cure ordinary lupus, nor is it a common experience. Dr. Mackey has noted two cases, in one of which the nose was affected, in the other the nose and scalp; ulceration was deep, indolent, and slowly progressive, in spite of caustic treatment; discharge was but slight, crusts formed at the edges, and the cases resembled true lupus, except that there were no tubercles, and the patients (men) were between forty and fifty years of age when the sores commenced. Both recovered quickly under the influence of iodide of potassium and mercurial lotions; but, although there was no history of syphilis, the probability remains in favor of its existence in similar cases.

Hydatid Cysts.—Dr. Tanner recorded a few cases in which these cysts wasted and were cured under the *internal* use of iodide of potassium, and although the relation of cause and effect may be questioned, there is some evidence of its possibility, and it deserves further inquiry (*Medical Times*, ii., 1872).

Meningitis (*? Tubercular*).—I have had several cases of meningitis that derived benefit from iodides, given alone or in combination. In one, a child, aged six years, ill for eight days, insensible, with dilated pupils, dysphagia, paralysis of one side, and convulsive twitching, getting worse under previous treatment, improvement began soon after commencing iodide of potassium, which was given in 5 to 10-gr. doses every four hours, and 5 min. of tincture of belladonna midway between. Recovery ultimately ensued, and the boy is now sixteen years of age. In another case of mine, aged eight years, the child had pain, vomiting, delirium, unconsciousness, convulsion, dilated pupils, tetanic stiffness of the neck-muscles, grinding of teeth, difficult respiration, slow, weak pulse, and every sign of fully developed meningitis, yet recovered under iodide of potassium and belladonna, with occasional doses of aconite. Dr. Leared recorded a case of recovery under 5-gr. doses of iodide of potassium when other remedies had been used without relief. He was satisfied as to the diagnosis of "tubercular meningitis." M. Rodet has recently recorded a severe case in a girl of eighteen recovering under daily doses of 4 to 5 grammes, and considers failure due to insufficient dosage (*Medical Record*, May, 1879). Other desperate, but successful cases are on record (*Edinburgh Medical Journal*, 1841; *London Medical Gazette*, 1842; *Medical Times*, i., 1859; *Bulletin de Thérapeutique*, August, 1861, etc.); and M. Golfin (Montpellier) narrates three cases of this malady which recovered from the second or third stage under frictions with an iodide of mercury ointment to the scalp. (Hydrarg. iodid. virid., gr. ij.; Potas. iod., gr. iij.; Camphoræ, gr. ij.; Cerat. Galeni, gr. xxxij.)

In one child, aged four and a half years, the symptoms showed death to be imminent: the head was drawn back, the face pale, pupils dilated and

immovable, swallowing power was lost; partial paralysis, convulsion, and profound coma were present; the pulse was scarcely perceptible. About forty hours after commencing the iodo-mercuric frictions, urine flowed, and the paralysis and convulsion gradually lessened; in the course of four days only headache and stupor remained, and by the fifteenth day convalescence had set in (*Gazette Médicale de Montpellier*, February, 1847). Niemeyer speaks favorably of iodic frictions in basilar meningitis. The degree of credence, however, to be given to such remarkable cases as the above must depend upon the accuracy of the diagnosis, for brain-congestion or brain-anæmia in children, and, still more closely, simple meningitis, may simulate acute hydrocephalus to some extent, and I have certainly seen improvement under local frictions with iodized ointment, and internal treatment by iodide, bromide, and belladonna.

Trousseau and many physicians of experience deny that the tubercular form is curable under any circumstances, and certainly a large majority of such cases end fatally. Dr. Wilks "has seldom seen any good results" (*Medical Times*, ii., 1868).

In one case of hydrocephalus Brainard practised injection of iodine into the ventricles many times, with temporary improvement, but the child ultimately died in convulsions.

Phthisis.—Chronic congestive conditions of lung following on acute inflammations are usually connected with the scrofulous diathesis—pneumonic phthisis especially. In such cases, benefit may be obtained from iodine preparations. I prefer the tincture; but the iodide of iron, or the iodide of ammonium, is useful, according to the case.

In the more acute form of tubercular phthisis, when the patient suffers from loss of flesh, quick pulse, high temperature, pain, cough, dyspnœa, and nocturnal sweatings, the tincture, given every four hours, and inhaled, as well as applied locally over the chest, offers a chance of arresting or ameliorating the disease. In some cases under my care, this treatment appeared to check the disease.

In tubercular phthisis, in the absence of acute symptoms, I have seen benefit from iodine and iodides, but have sometimes noticed hæmoptysis following their use, and therefore recommend caution in cases disposed to hemorrhage.

Earlier observers—Chevallier, Elliotson, Bardsley, and others—thought iodine really curative in consumption. It can certainly lessen pulmonary induration and modify the irritative conditions of the bronchial mucous membrane and the character of expectoration; in fact, I have seen most symptoms improve under its use, but this must be supplemented by hygiene and generous living. Dr. Cotton's experience at Brompton Hospital was not so favorable: weight was seldom gained under iodide of potassium—generally diminished; dyspepsia was sometimes induced; usually, no definite effect could be traced (*Medical Times*, ii., 1859). Dr. Julius

Pollock, on the other hand, found the remedy very serviceable, and his patients gained weight under its use.

I have noted most benefit in cases of *chronic phthisis*, and especially when a syphilitic taint existed. Dr. B. W. Foster suggests that it acts by stimulation of the pancreas, thus promoting assimilation of fatty food, and Claude Bernard proved its elimination by that gland. Iodine inhalations in phthisis have proved of great value in my experience, exerting a disinfectant, and to some extent a resolvent action. It is important to guard against soreness of mouth and undue irritation of the air-passages during their use.

Bronchitis.—In the subacute and chronic stages, iodide of potassium, or of ammonium, relieves by an alterative action on the bronchial mucous membrane, thinning and ultimately diminishing the semi-purulent tough secretion. They may, sometimes with advantage, be combined with antispasmodics and other expectorants. In weakly subjects, the iodide of ammonium, in doses of from 2 to 5 gr. every four hours, may act better than the potassium salt. When there is an increase of temperature, aconite also should be given in doses of from 1 to 3 or 5 min. every two to four hours. If an expectorant is required, tartar emetic should be chosen. The dose should be small and frequent, and care should be taken to avoid emesis. With ordinary precaution in the regulation of the dose, neither aconite nor antimony need be dreaded for their depressing action, and it is remarkable how favorably these medicines act in conjunction with iodides.

Asthma.—I have known iodide of potassium relieve many asthmatic patients, and Horace Green (1860) found it to be the main ingredient in a secret and successful remedy for asthma. Trousseau and Jaccoud speak of its value, and M. Sée records valuable observations upon twenty-four cases watched for a long time. Four of these were children, four old people, the others adults; the daily dose varied from 22 to 45 gr., it being reduced as improvement progressed; if given some hours before the usual attack, this was often prevented; if given during it, respiration was rendered free in one to two hours. Chronic asthma with emphysema was also benefited by the remedy; inhalations of the iodide of ethyl, six to ten drops several times daily, and the occasional use of opium or chloral in these latter cases, were with advantage conjoined with the treatment (*Medical Record*, 1878). Dr. Hyde Salter has observed benefit from iodide of potassium in full doses—15 to 30 gr.—every two to four hours, in very diverse cases of asthma. I think that such attacks as are connected with catarrh and are relieved by free secretion, and in which the nerve-symptoms are reflex, rather than primary, show the best results from this remedy. I have known it efficacious in asthma connected with amenorrhœa and uterine congestion, and also in the asthma of rheumatic and gouty subjects. In an interesting case in a very rheumatic patient,

the asthmatic attack was relieved by 4-gr. doses of iodide; but severe pain in the region of the kidney followed, with secretion of scanty, acid urine; this occurred more than once, and was only relieved by free excretion of alkaline urine under appropriate remedies (*British Medical Journal*, January, 1875). In this case the drug was supposed to cause renal congestion by increasing the absorption of waste nitrogenous material, and consequently the amount to be eliminated. I have known iodine itself produce renal congestion in some individuals.

Dr. C. J. B. Williams has seen a very large number of asthmatic cases relieved by iodide and by carbonate of potash with stramonium (*Medical Times*, i., 1872), but most of M. Sée's cases were relieved by the iodide alone. Dr. Reed recommends the liquor iodinii in "dry asthma" of constitutional character and without obvious exciting cause (*Medical Record*, 1879).

I believe that the drug acts directly on the mucous membrane, relieving its congested state by promoting a thin, fluid secretion; but, independently of any theory, it will be found worthy of trial in any rebellious case.

Catarrh.—Iodide of ammonium, in 1-gr. doses every two to four hours, is a good remedy in ordinary acute catarrh.

Hay-Asthma. — In this distressing malady, iodide of ammonium, combined with arsenic, will often give a better result than either remedy alone. Weak iodine solution should be injected into the nares, or, what is more convenient, the vapor of iodine, or of carbolate of iodine, should be inhaled by the nostrils, as recommended by Melville (*Lancet*, ii., 1864).

Sore-Throat.—In cases of follicular tonsillitis, or when spots of ulceration about the buccal mucous membrane are induced by cold, small doses of iodide are useful.

Croup—Diphtheria.—The tincture of iodine, as well as the iodides, are very valuable in these disorders, especially in their early stages; they should always be given in conjunction with aconite, and occasionally the judicious use of an emetic is serviceable. I trace the benefit following the use of the iodide partly to a local effect, rendering the false membrane less tenacious, and partly to an eliminant action on the kidneys. Its use by inhalation has already been mentioned, and should be strictly attended to (*v.* p. 72).

Albuminuria.—The prolonged administration of iodide of potassium in chronic Bright's disease is said to have retarded fibroid changes in the kidney, and induced general improvement in nutrition (Bartholow). Dr. Créqui (Brussels) recommends it for the second or parenchymatous stage. Using commonly 6 gr. or more daily, he has sometimes given as much as 6 dr. in the day, with bismuth or opium to control irritative effects. He presumes the iodide acts by limiting morbid secretion in the renal tubules

(*Lancet*, i., 1871). In subacute cases, with dropsy, I have frequently used this remedy in doses of 3 to 4 gr., and have seen apparent advantage from it. I think it hastens absorption of inflammatory products, but, from what has been already stated as to the possibility of its causing renal congestion (*v.* p. 67), it must be considered unsuitable in acute nephritis, unless in fractional doses.

Ascites—Anasarca.—Not only in renal dropsy, but in that dependent on hepatic disease, and certainly in general anasarca independent of organic malady, iodide of potassium or iodide of iron is useful. Frictions with iodized liniment should be combined with the internal treatment. Injections have sometimes been used (*v.* p. 75).

Aneurism.—In those cases of thoracic and abdominal aneurism, in which surgical treatment is impossible or highly dangerous, the clinical results obtained by iodide of potassium should not be ignored. Nélaton recorded marked relief to the signs and symptoms of an innominate aneurism under the use of this remedy, which he gave empirically at the request of the patient; and Bouillaud, following up this clue, obtained good results in aneurisms of the carotid and thoracic vessels (*Medical Times*, i., 1859).

Chuckerbutty, in Calcutta, published three cases relieved, in one of which the aneurism was already projecting through the sternum when the drug was commenced, and Dr. W. Roberts and Mr. Windsor recorded some equally striking results about the same time (*British Medical Journal*, ii., 1862; i., 1863).

It is, however, to Dr. Balfour that we are most indebted for drawing professional attention to this subject (*Edinburgh Medical Journal*, 1868–1869). He summarizes 15 cases, all of which, save one, were relieved, and in 12 the external tumor was actually lessened and the sac partly consolidated. In one of his earliest patients the bulging, which was evident between the second and third ribs, disappeared after a few weeks' treatment with 30-gr. doses thrice daily, and this dose was continued for nine months "without any unpleasant symptoms," but with complete subsidence of aneurismal suffering. The same man had not improved under previous doses of 20 gr., and Dr. Balfour points out the importance of pressing the drug to saturation before considering it inert. It is very quickly eliminated—large doses within two or three days—and many of his patients took 20 to 30 gr. several times daily. In a few, coryza and headache were quickly induced, and 5 gr. only were tolerated, but, as a rule, no worse symptoms were caused by large than by small doses. Additional evidence in favor of this treatment has been furnished by Dr. W. Roberts, Dr. Shapter, and others (*Medical Times*, 1874; *British Medical Journal*, 1873–74), and recently Dr. Philipson has reported a cure of an abdominal aneurism (*British Medical Journal*, i., 1878).

It seems to me no argument against such cases to say, with Dr. Bris-

towe, that any remedy which coagulates the blood in an aneurismal sac must tend to coagulate it elsewhere, and is therefore inadmissible; or to note with Mr. Holmes that aneurism may sometimes develop in patients already under the influence of iodide (*Medical Times*, i., 1872). This is only saying that the remedy is not infallible, and that its mode of action, whether on the composition or vital condition of the blood (Chuckerbutty, Roberts), on the nervous system (Balfour), or on the walls of the sac, is not yet clear. I have myself seen remarkable advantage from its use, and suggest, in addition to the above explanations, a possible anti-syphilitic effect—for the occasional connection of syphilis and aneurism is sufficiently proved by modern research.

Chronic Inflammatory Indurations.—In simple chronic enlargement of glandular organs, the liver, the spleen, the mammary gland, or the testes, iodine is often of more service than any other medicine. The cause may be syphilis, struma, or malaria, and yet the same remedy be applicable.

I generally recommend 1 to 5 min. of tincture thrice daily for a long period, though sometimes iodides are better borne. External painting, or iodine compresses, should be used at the same time. Iodoform ointment, or iodoform collodion, is also to be highly recommended (*v.* pp. 70, 73).

Bronchocele.—In simple soft goître, in which malady, indeed, the reputation of iodine was first acquired, I consider it almost a specific. In recent cases, 1 to 5 min. doses of the tincture produce the best results, for, if unduly large quantities be given, the swelling becomes hard, tender, and painful. In more chronic cases already indurated, large doses—¼ to 1 gr. of iodine—may be given in conjunction with its external use (*v.* p. 71); some astringent syrup, *e.g.*, of cinchona or orange-peel, should be added to prevent derangement of stomach. Mr. Bryant has known goîtres rapidly disappear under the influence of an iodized atmosphere, obtained by simply placing iodine in a perforated box in the patient's room; he recommends also the local use of an ointment of iodide of ammonium ("Practical Surgery," 3d Ed.).

In *Exophthalmic Goître* I have also seen a limited amount of success from the internal use of iodine tincture, the palpitation being frequently relieved by small doses.

Uterine Fibroma.—Fibroid growths or indurations, especially those originating in the cervix, *i.e.*, in the more glandular and secretory part of the uterus, often improve under the use of iodine or iodides. Dr. Ashwell long since described them as "melting down" under this treatment (Guy's "Reports," vol. i.), and mineral waters, of deserved repute in such cases, owe their efficacy to a combination of iodides and bromides (*v.* p. 118).

Direct injection of the drug into the growth is also a valuable resource

with due precaution. I have injected 10 to 20 min. of an aqueous solution of iodine (half the strength of the British Pharmacopœia tincture) in twenty-three cases of uterine fibroids of large size, and repeated the operation several times with encouraging results. Nearly all improved considerably under the treatment, and the tumors disappeared, in five instances, within twelve months of the first injection. Two cases suffered considerably from local inflammation, obliging the treatment to be discontinued after the third and fourth injections respectively; but both these cases eventually improved more quickly than any of the others.

In *Passive Uterine Congestion* tincture of iodine is often useful; and Dr. J. B. Schmidt has written to recommend minim doses for chlorotic subjects suffering from headaches, frequent menstruation, and diarrhœa ("Medico-Chirurgical Transactions," i., 1871).

Amenorrhœa—Sterility.—When these conditions depend on functional causes, congestion, torpor, debility, etc., iodine and the iodides are useful. I have often proved them so in the former condition, and sometimes in sterility they exert a stimulating effect on the uterus, possibly because of their elimination by the mucous membrane.

Vomiting of Pregnancy, etc.—I have known 1 to 5 min. doses of the tincture arrest the capricious vomiting, also the pyrosis and heartburn of pregnancy, possibly by a stimulant effect on the gastric membrane. Its local application to the cervix, conjoined with its internal administration, often acts with advantage. Dr. Eulenburg recommends 10-min. doses as very serviceable, but I prefer the smaller doses repeated every two or three hours.

Atonic Diarrhœa, Dysenteric Diarrhœa, etc.—I have obtained benefit from similar doses in atonic diarrhœa, and in the form which occurs during phthisis. They have been recommended in cases of passive hemorrhage and serous intestinal flow dependent on "paralysis of the ganglionic centres" (Schmidt: *Medico-Chirurgical Review*, i., 1871); also in later stages of typhoid fever. Iodized enemata have been used in dysentery to relieve tenesmus (*Medical Times*, i., 1857); 1 to 5 min. doses of the tincture, given every four hours with cinchona, will cure the tormina and the tenesmus of dysenteric diarrhœa.

Preparations and Dose.—*Tinctura iodi* contains iodine, ½ oz., iodide of potassium ¼ oz., rectified spirits 20 fluid oz.: dose, 5 to 20 min. *Liquor iodi* contains 20 gr. iodine, 30 gr. iodide of potassium, in 1 oz. water: dose, 3 to 10 min. *Linimentum iodi* contains iodine 1¼ oz., iodide of potassium ½ oz., camphor ¼ oz., rectified spirit 10 oz. *Unguentum iodi:* iodine 32 gr., iodide of potassium 32 gr., proof spirit 1 dr., prepared lard 2 oz. *Vapor iodi* (inhalation of iodine) contains tincture of iodine 1 dr., water 1 oz.; heat slightly for inhalation of vapor. *Iodoformum:* dose, ½ to 2 gr. in pill, or pastilles—as made by Messrs. Bullock, containing 2 gr. in each (*Medical Times*, ii., 1878). *Unguentum iodoformi:* 1 part in 8.

Collodium iodoformi: 1 part in 16. A *suppository* containing 20 gr. with cacao butter is officinal in the German Pharmacopœia. *Potassii iodidum, sodii iodidum:* dose, from ½ to 30 gr. and upward in syphilis; average dose, 3 to 5 gr. The dose of the *ammonium* salt is somewhat smaller.

[Preparations, U. S. P.—*Liquor iodinii compositus:* iodine 360 gr., iodide of potassium 1½ troyounce, distilled water 1 pint. Dose, 2 to 6 minims. *Tinctura iodinii:* iodine 1 troyounce, alcohol 1 pint. Dose, 1 to 10 minims. *Tinctura iodinii composita:* iodine ½ troyounce, iodide of potassium 1 troyounce, alcohol 1 pint. Dose, 5 to 15 minims. *Unguentum iodinii:* iodine 20 gr., iodide of potassium 4 gr., water 6 m., lard 1 troyounce. *Unguentum iodinii compositum:* iodine 15 gr., iodide of potassium 30 gr., water 30 m., lard 1 troyounce.

Iodoformum.—No officinal preparations.—*Potassii Iodidum.*]

Administration.—Opinions are still divided as to the best time for giving iodides with relation to food.

Dr. Parkes and others recommend them to be taken before meals, in order to prevent decomposition by acids, and to secure dilution with mucus. Some give them at bedtime in effervescence; and again, others find them better borne by a full stomach. All agree that they should be freely diluted, and not taken when there is much starchy food in the stomach, and if there are not febrile or acute gastric symptoms, a bitter infusion or tincture is a good vehicle; in other cases milk is very suitable. Large doses sometimes produce less iodism than small ones (Althaus), and arsenic is to some extent corrective of the unpleasant results (*British Medical Journal*, ii., 1871). Ethereal oil, such as that of peppermint, diminishes the mal-odor of iodoform (*Medical Record*, 1879).

Adulterations.—The iodides sometimes contain iodates of the respective alkalies, and not unfrequently an excess of water, and, after keeping, free iodine is developed to some extent (*v.* p. 59); but of six chance specimens analyzed all were found pure (*British Medical Journal*, ii., 1870).

BROMUM—BROMINE, Br,=80.

This element is contained in sea-water and in some saline springs, as in those of Ashby, Birtley (Durham), Woodhall, and Kreuznach, also in sea-weed and in molluscs.

Preparation.—Bromine is chiefly obtained after the crystallization of common salt, from "bittern" or sea-water (in which it exists as bromide of magnesium, sodium, and potassium), by passing through the liquid, chlorine gas, which sets free the bromine. The mixture is then

shaken up with ether, which dissolves the bromine and rises to the surface and is decanted. To this ethereal solution caustic potash (or soda) is added, and the ether evaporated off by heat. The crystals of bromide of potassium thus obtained are treated with sulphuric acid and manganese oxide, and the liberated bromine is evaporated and collected in cooled receivers.

The reactions are:—(1) $MgBr_2 + 2Cl = MGCl_2 + 2Br$. (2) $6Br + 6KHO = 5KBr + KBrO_3 + 3H_2O$. (3) $2KBr + 3H_2SO_4 + MnO_2 = 2KHSO_4 + MnSO_4 + 2H_2O + Br2$.

The potassæ bromas ($KBrO_3$) formed in the second reaction is converted into potassium bromide (KBr) by ignition before the final process.

Characters and Tests.—Bromine is the only non-metallic element which is liquid. It is of brownish red color, very volatile, and emits an irritating, very fetid vapor, whence its name, Βρομος, a stench. It boils at 145.4° F. (Pierre) (139.1° F., Bolas and Grove), not 117°, as stated in the *British Pharmacopœia*. Iodine, chlorine, and alkalies decolorize bromine, with formation of bromides and bromates, and in contact with hydrogen-compounds it forms bromhydric acid. Solutions in alcohol and ether (which liquids dissolve bromine readily) lose their color in a few days with formation of the same acid. Bromine should be kept in a stoppered bottle, and under water, in which it is only slightly soluble. At 32° F. it forms with water a crystalline hydrate.

Physiological Action.—Bromine coagulates albumen and combines with it in a definite proportion of Br. 23, albumen 96, which compound is soluble in caustic potash, and is colorless (Glover: "Harveian Essay," 1842).

Undiluted bromine quickly oxidizes and destroys organic tissues, forming a brownish slough. With fatty substances hydrobromic acid is developed. Bromine vapor is intensely irritating to the air-passages, possibly on account of its liberating free ozone on contact with moist mucous surfaces exposed to air. It may cause coryza, or even laryngitis, bronchitis, or pneumonia, and may destroy the sense of smell.

When taken internally in doses of one to two drops, well diluted, it has a taste "truly horrid" (Glover), and causes weight and heat at the stomach, often colic, shooting pains in the limbs, and itching in the extremities; but after an hour or so these symptoms are succeeded by a general sense of comfort and stimulation. Larger doses may cause gastritis with symptoms of intense irritation, prostration, and collapse. Independently of this *local irritant* effect, the physiological action of bromine, after absorption, is exerted mainly on the *lymphatic* and *glandular* systems, their functional activity being increased.

Köhler mentions several experiments which have been made with bromine, and says, "that, independent of its local action, it exerts, if taken in small doses for some time, a strong action upon the brain, viz., depres-

sion of the mental functions, sleepiness, stupor, prostration, and a state resembling alcoholic intoxication." On the other hand, bromine does not show the peculiar depressing action of its potash salts on the heart, nor their special effect on the spine of lowering its reflex irritability.

THERAPEUTICAL ACTION (EXTERNAL).—*Hospital Gangrene—Erysipelas.*—The value of bromine as an escharotic and caustic in these maladies was conclusively shown during the American civil war, by Surgeon Goldsmith. The formula commonly employed was: "bromine, 1 oz.; bromide of potassium, 160 gr.; water, 4 oz." After thorough cleansing of gangrenous wounds this was applied, and, although very painful for a time, the pain was mitigated by bathing, and the malady was arrested better by this than by any other means (*Medical Times*, ii., 1863, 526). The same application was found valuable in diphtheria and erysipelas, and the liquid, when exposed in shallow vessels, served also to disinfect hospital wards.

Mr. Marshall and Mr. Southam used a solution of 1 scruple of bromine in 1 oz. of spirit for unhealthy wounds, and found it useful, but very painful; its offensive smell is also a drawback to its employment (*Medical Times*, ii., 1868, p. 93). The pure drug has also been applied, and acts well in similar cases, but requires special precaution to carry the vapor away from the patient (*Lancet*, ii., 1868).

Chancre—Epithelioma.—In the few cases where a chancre can be, with advantage, destroyed in an early stage, bromine is one of the most efficient agents for the purpose.

Dr. Wynn Williams and others have reported very satisfactory results from the use of local bromine injections into the substance of epithelial cancer affecting the cervix uteri (*Medical Times*, ii., 1866, p. 488, and ii., 1870, p. 255). Dr. Williams uses a solution of 12 min. in 1 dr. of rectified spirit, injecting it through a speculum by means of a long glass syringe having a platinum point (the nostrils of the operator should be plugged with cotton-wool). There can be no question of the good results obtained by Dr. Williams, but, as he restricted his method to cases "in which the uterus was not fixed," some doubts were thrown on the diagnosis of cancer by Dr. Playfair and others.

Strumous Glands—Chronic Skin Diseases.—Ointments and lotions containing bromine have been applied to glandular swellings and ulcerations, and to patches of chronic eczema, with moderate success (Bonnet: *Bulletin de Thérapeutique*, 1837), but severe symptoms of irritation of lungs and stomach have sometimes followed, and iodine applications are more generally adopted.

Nasal Catarrh—Hay-Asthma—Ozæna.—Brominized inhalations are of value in these disorders, and may be employed in the manner recommended by Bartholow. Half a drachm of bromine is mixed with four ounces of alcohol, and a small quantity of this placed in a wide-mouthed

phial and vaporized by the warmth of the hand, furnishes a diluted vapor which should be drawn up into the nasal passages.

Diphtheria—Membranous Croup.—Brominized inhalations and external applications have been successfully used, especially by German physicians in these maladies, and in diphtheritic vaginitis (*British Medical Journal*, ii., 1872). Ozanam used also an aqueous solution internally (*British and Foreign Review*, April, 1869), and I have myself seen excellent results with this combined method of treatment, diphtheritic membrane disappearing under it. I have employed the inhalations and bromine internally every three or four hours, using one or two drachms of a solution containing eight drops to the ounce, even when the disease had extended to the bronchi, and great prostration had set in; and sometimes I have used the vapor and local applications of bromine while giving iron internally, also with very good results.

Redenbacher has reported two successful cases in which bromine and bromides were useful (*British Medical Journal*, i., 1879).

THERAPEUTICAL ACTION (INTERNAL)—*Chronic Arthritis.*—Andral treated this disorder by giving bromine at first in 2-drop doses, but later with as many as 60 drops in twenty-four hours. The gastric irritation, however, was too severe to make such treatment desirable.

Struma.—Bonnet recommended 5 to 10 drops daily in cases of glandular scrofulosis, conjoining local applications (*Bulletin*, 1837), but the internal use of bromine is practically superseded by that of its compounds. It is possible, however, that smaller and more frequent doses of bromine than have hitherto been prescribed might give better results, with avoidance of gastric irritation.

COMPOUNDS OF BROMINE.

POTASSII BROMIDUM—BROMIDE OF POTASSIUM, KBr, = 119.

PREPARATION.—By adding bromine in slight excess to liq. potassæ, and afterward heating with charcoal, dissolving, and crystallizing. In the first part of the process a mixture of bromide and bromate of potash is formed, $6KHO+Br_6=5KBr+KBrO_3+3H_2O$, and in the second part the bromate is deoxidized, the bromide remaining unaffected.

CHARACTERS AND TESTS.—It occurs in cubical crystals, resembling those of the iodide, but smaller. When well kept they are transparent or white, but commonly have a tinge of yellow from some free bromine. They have a saline, bitter taste, and high diffusion power. They contain 66 per cent. of bromine. Chlorine water added to the crystals liberates bromine, which will impart an orange-red color to chloroform, ether, or sulphide of carbon. The starch-test would detect iodine, which used to be a frequent adulteration.

AMMONII BROMIDUM—BROMIDE OF AMMONIUM, NH_4Br, =98.

PREPARATION.—By saturating hydrobromic acid with ammonia—$HBr \times NH_4HO = NH_4Br + H_2O$.

CHARACTERS AND TESTS.—It occurs in white, colorless crystals, which gradually become yellowish; is rather more disagreeable to the taste than the potassium salt; answers to the tests mentioned, but effervesces with acids.

Sodii Bromidum—Bromide of Sodium, NaBr (not officinal). Crystallizes like the analogous salt of potassium; it is less bitter in taste; contains more bromine (78 per cent.).

Lithiæ Bromidum—Bromide of Lithia (not officinal) is crystalline, white, soluble, and contains a larger proportion of bromine than any other compound (92 per cent. Weir Mitchell).

Calcii Bromidum—Bromide of Calcium (not officinal) is white, very soluble, in fact deliquescent. Readily decomposes on exposure, becoming brown in color; occurs in Kreuznach and Vals water; is less stable than the potassium salt, and therefore more active (Hammond).

Magnesiæ Bromidum—Bromide of Magnesia.—This salt is the main source of the metalloid, and is especially abundant in the water of the Dead Sea; it is found also in the Ashby and Kreuznach waters.

Besides these, there are many *metallic bromides*, such as those of iron, zinc, mercury, and lead; and many *organic bromides*, such as those of camphor, morphia, quinine, and strychnia. Their properties are chiefly those of the base, but modified somewhat, so as to act more favorably on the nervous system. *Bromhydric acid* is another combination recently introduced (*British Medical Journal*, July, 1876) (*v.* p. 119). *Hydrobromic ether* is said to be an efficient and comparatively safe anæsthetic (Levin).

ABSORPTION AND ELIMINATION.—The alkaline bromides are readily absorbed, and have been found in the urine and saliva five minutes after a dose of 15 gr. (Rabuteau); in ten minutes' time the reactions were very manifest. Bowditch drew blood from the carotid of an animal six minutes after 10 gr. had been taken, and calculated that even in that time a third of the dose had passed into the circulation (*Boston Journal*, October, 1868). They are usually eliminated *unchanged*, and Voisin has obtained cubical crystals of the potassium salt from the urine of patients taking it. The rate of elimination varies. In some experiments already mentioned, the urine gave traces of the drug in ten minutes; in others thirty minutes was the earliest period, in others twenty-five hours (Bowditch). The excretion of single large doses is usually complete in one or two days (Chauvet, Amory), though minute quantities have been detected in the urine for three or four weeks afterward (Rabuteau). If the drug

has been taken continuously for some time, the period of its excretion is prolonged: thus Namias found it continue for fourteen days (*Gazette Hebdomadaire*, 1868), and renal disease so far impedes its excretion that upwards of thirty days may be required for its completion. Dr. Stevenson "detected bromides in the urine of a child, passed about four weeks after the medicine was discontinued" (Lees: "Pathological Society's Transactions," 1877).

As evidence, also, of the slow elimination of these salts, Drs. Crocker, Lees, Barlow, myself and others, have noted the increase, or even the chief development, of the rash sometimes produced by them after the discontinuance of the drugs. The elimination of bromides is certainly *slower* than that of iodides. It occurs not only by the kidneys and the saliva, but also by the mammary, lachrymal, and sudoriparous glands, and by mucous membranes—by the last especially in the case of the ammonium salts. In exceptional instances the salts have been decomposed in the system and free bromine eliminated in the breath. The alkaline compounds do not usually pass by the fæces unless diarrhœa occur; but, if *metallic* bromides be taken, the *metal* passes chiefly by the bile and the motions.

Thus, when experimenting with bromide of iron, Namias found bromine abundantly in the urine, but iron scarcely at all. The same observer, examining the body of a man who died while taking bromide of potassium, found that salt in all the fluids, as well as in the brain, liver, lungs, and other viscera (*Comptes Rendus*, tome lxx.). After very large doses, an unabsorbed portion has been found in the intestine.

Physiological Action (Internal).—*Digestive System.*—Doses of 5 to 15 gr. of the alkaline bromides are well borne by the stomach, but upward of 20 or 30 gr. will often cause irritation and nausea, with sense of weight and coldness, or later of warmth. At first the gastric secretions are rather lessened and appetite slightly increased, but after a time there is anorexia, and gastric catarrh and diarrhœa may occur, especially with the potassium salt. Bromide of sodium increases thirst as the chloride does. The sensibility and the reflex movements of the *fauces* and *pharynx* become much lessened under the full influence of the bromides, and even from their continued local application. If, however, these parts are inflamed, a strong solution may prove very painful.

Nervous System.—The action of bromides on the nervous system, especially of the lower animals, has been carefully studied by many observers, but with different and somewhat confusing results. Thus, while Damourette, Pelvet, and R. Amory conclude that the functions of nerve-tissue become paralyzed by its direct local application (*Bulletin Thérapeutique*, tome lxxiii., and "Essay on Bromide," 1872), Saison finds no trace of such paralysis (Du Bromure: Thèse, 1868); and while Laborde and Purser are satisfied that reflex function is early abolished (*Archives*

de Physiol., tome i., and *Dublin Journal*, 1869), Bill holds this to be unproven, and argues that results with frogs are but little guide to effects on men (*American Journal*, July, 1868).

I believe myself, that in this instance there is much analogy in the action of the drug on men and animals, and a careful consideration of the evidence before us warrants the following statements.

In *batrachians*, the bromides, when injected under, or absorbed through the skin, after producing spasm, exert a local paralyzing effect on the neighboring tissues, whether nervous or muscular. If the injection be made close to the brain or to the cord, the *centre* which is *nearest* will be paralyzed soonest; but if absorption occur at a distance, *e.g.*, through the web of foot, then *reflex power* is *first* lost, so that pinching or irritation does not excite the usual contractions. The periphery of sensory nerves loses its sensibility very soon afterward; then the motor tract of the cord and motor nerves are affected, and lastly the cerebrum. Most of the characteristic effects of the drug may be seen on frogs after the medulla is divided from the brain, but, if it be left undivided, the persistence of some voluntary power, after the cessation of reflex function, is made evident by movements even after apparent death.

In *warm-blooded animals* the demonstration of early loss of reflex power is not so complete, but there is evident impairment of sensibility and of cerebral action, with partial paralysis, especially of the *hind* limbs.

In *man*, the earliest effects of *full* doses on the nervous system are usually seen in impaired sensibility, especially of mucous surfaces, such as the fauces and pharynx, the conjunctiva, and the urethral membrane. It is possibly most marked in these regions because the drug is largely eliminated there, but loss of tactile sensibility is also sometimes observed in the palms and the soles. Affection of the nerve-centres is shown, sooner or later, by languor, lassitude, and drowsiness; giddiness is complained of, and exceptionally there may be cerebral excitement; mental working power is temporarily impaired, so that ordinary accounts become puzzling and memory fails. The amount of the drug that produces such symptoms varies in different persons. Dr. Lockhart Clarke has noted them from half-drachm and drachm doses, but usually they are not seen until after much larger quantities have been absorbed. The impaired nerve-condition is known as "bromism," and when developed in an extreme degree, the special senses, sight and hearing, are greatly dulled, reflex and motor power are almost wholly lost, and the cerebral state is one of absolute apathy and indifference bordering upon idiocy. As a rule, these serious symptoms subside quickly on omission of the drug.

In a case said to be of chronic bromine-poisoning there were vertigo, amaurosis, and some loss of co-ordination and sensation (*Medical Record*, 1879).

In seeking for an explanation of the *mode* of action of bromide, it is clear that we must go farther than the contraction of minute vessels in the nerve-tissue; we may grant that it produces, in certain doses, such a contraction, and may therefore believe that it irritates or stimulates vaso-motor nerves, but, besides this, must be admitted, for toxic doses at least, a *direct* sedative depressing action on the cerebro-spinal system, both central and peripheral, and, *in some instances*, the action on the vaso-motors is also paralyzing, and is accompanied by relaxation of capillaries and local congestions. It is thus that we may explain the exceptional occurrence of diarrhœa or diuresis under bromides, and more particularly the retinal congestions found by Dr. Nicol after doses of ½ to 1 dr. (*Medico-Chirurgical Transactions*, ii., 1872); but this point requires further investigation.

Nothnagel says the temperature always goes down after large doses in men and animals—after 10 grammes (2½ dr.) by 0.5° to 0.8° C., after 15 grammes by 1.2°C. (Krosz).

Circulatory System.—In a frog, if strong solutions be injected near the cardiac region, the heart is suddenly arrested in diastole, but under a slower *distal* absorption this does not occur, nor is there evidence of the specific paralyzing effect upon the heart contended for by Eulenburg. On the contrary, the heart has been found beating one or two hours after complete paralysis of the nervous system and of respiration (Damourette, Saison). The heart-action is rendered slower, but, as a rule, the capillaries are narrowed *before* this slowing. It is not the soaking through of the cardiac muscles by bromide of potash that produces these effects (as it does in the experiments on the frog mentioned above), but the gradual lowering of the spinal reflex irritability. The observers just named, as well as Meuriot, Hammond, and Amory, have witnessed the narrowing of vessels in the web, the tongue, or the brain of frogs or dogs; but others have failed to see this, and Dr. H. C. Wood considers the present proof insufficient; neither does the observation that divided capillaries of a brominized frog bleed less than normal ones seem free from criticism, for he suggests that lowered heart-action would account for lessened bleeding. But, these observations apart, I think the surface-pallor that follows the use of bromides, and the lessening of secretion and discharge, point strongly in the same direction (narrowing of vessels). There is also post-mortem evidence of lessened blood in capillaries when influenced by bromide (Saison), and we may quote, too, the clinical fact that bromides relieve many forms of *capillary congestion*, especially cerebral and uterine, whereas in patients with cerebral *anæmia* the effects are often distressing. Thus, while Dr. Wood considers capillary contraction to be "somewhat probable," I hold it to be more clearly ascertained.

That the heart-action and the general circulation are slowed in the lower animals is also evident from many experiments (Damourette and

Pelvet, loc. cit., and Schouten: Schmidt's *Jahrbuch*, Bd. cliv., p. 11). This is more marked with the potassium salt than with the others, and may be largely credited to the alkali; the bromide of sodium has comparatively slight effect in this direction (Eulenburg, Rabuteau). In man, the depressing effect of any bromides on the circulation is not constant. Pletzer noticed it (Schmidt, August, 1868), and Bartholow records a depression of 10 to 20 beats per minute after a dose of 2 dr.; but Dr. Bill, Dr. Voisin, Dr. Russell Reynolds, and others have failed to observe such a result with doses of 20 gr. and upwards, continued for some time. It is evident that circulatory depression is a less constant and characteristic effect of the bromides than nerve-sedation.

Generative System.—Speaking generally, we may say that bromides act as sedatives upon the genital system, and diminish the sexual feelings and the power of erection, though the secretion of the testicles is not lessened (Rabuteau). But we must recognize that genital excitement may arise either from *eccentric* cause (as urethral irritation, rectal or ovarian congestion, etc.), or from a *centric* cause in the mind, cord, or brain itself. It is the former that is controlled by bromide, and there is some reason to think with Dr. Bill that its effect is *mainly* local, and exerted through the mucous membrane of the urethra, although, no doubt, some effect may be attributed to a lessening of congestion in the spinal cord (*v.* p. 113). The degree of sedation induced by bromides varies in different men and in male animals, and is shown only under the influence of large doses. It is said not to be exerted in the female sex, though there is clinical evidence of these medicines lessening uterine and ovarian congestion and irritation.

Action on Secretion and Excretion.—The *primary* effect of moderate doses of bromide is to lessen most of the secretions (Bowditch and others), although, as a *secondary* effect, or after very large doses, they may be increased. There is no lachrymation, salivation, or catarrh from a pure salt, as there is from the iodides, for bromides are more stable, and, although also eliminated by mucous membranes, do not part with free bromine on their surface. The mouth is rendered rather drier than usual, especially by the sodium salt. The amount of mucus in the intestinal canal is also lessened, so that constipation is not infrequent at first. The secretion of milk is lessened by the internal and local use of bromide of potassium (Tyler Smith: *Medical Times*, i., 1861). With regard to the amount of urine excreted, the usual result is that with small or moderate doses no increase can be made out, while with large or long-continued ones, diuresis occurs. Dr. Bowditch suggests that a *secondary* hyperæmia is determined more readily in the kidneys than in other parts, and Pletzer has reported albuminuria in some instances.

Bromides tend to lessen vesical irritability, and so to render micturition less frequent, though the amount passed may be really larger than

usual. On the other hand, very large doses may so far paralyze the sphincter as to occasion incontinence.

Excretion of Urea and Carbonic Acid—Action on Nutrition.—From the experiments of Dr. Bill and Professor Rabuteau, it appears that tissue-change is *retarded* under the influence of bromides. The former especially noted that the carbonic acid eliminated was decidedly less than normal, and this independently of diminished nerve-power, and not proportionately to the dose, as it is with morphia and its congeners. For some time after ceasing the medicine the excretion of the gas was increased, implying that, for a time, "the way through the lungs was barred," and this he attributed to vital causes, "limited in their seat and effects to nerve-elements in the pulmonary mucous membrane."

Rabuteau found that while his average daily excretion of urea was 21.25 grammes, the mean amount passed while he took a daily dose of 15 gr. of bromide of potassium was 19.52 grammes; for a fortnight after omitting the drug it remained at about 20 grammes; in the third week it resumed a normal proportion, and in the fourth week exceeded this. Rabuteau connected the primary result with slowing of circulation and respiration; it was not accompanied by increased quantity of urine.

Dr. Gibb found the ammonium salt diminish body-weight "by favoring absorption of fat" (*Lancet*, i., 1863). If this be so, we should expect carbonic acid and urea to be increased in amount (contrary to the above results from the potassium salt); but he gave only small doses (3 to 5 gr.), and his results need confirmation. Bartholow found that assimilation was *retarded* by the continued use of bromides, and he traced emaciation to this cause. I have sometimes noted emaciation from these medicines; but it is by no means invariable, as shown in ten patients at Hayward's Heath Asylum, who took daily doses of less than 1 dr. of the potassium salt. Ordinary secretion and excretion were not affected, but all these patients increased in weight; and in another series of patients who took more than 1-dr. doses, some lost weight and some did not (Dr. Williams). The increase of weight would accord with the conclusions of Bill and Rabuteau, but minute analyses were not made.

Cutaneous System.—Perspiration is diminished under bromide of potassium. Various kinds of *eruption*, erythematous or acneiform in character, are commonly traced to this drug, and although several observers maintain that they are wholly due to some contained *iodide*, they seem in greater or less degree inseparable from bromide medication, and occur with almost equal frequency after the ammonium, sodium, or other compounds.

They affect mostly the face, the arms, the back, and the buttocks, but may be general. They present papules, vesicles containing sebaceous matter (seborrhœa—Fox), or pustules, and even crusted tubercles of carbuncular character, and have been termed "confluent acne" (Cholmeley)

and "molluscoid acne" (Neumann). Voisin distinguishes five different kinds of "bromide rash" (*Archives Générales*, 1866–67). Usually there is a hard, red swelling, with a small point of suppuration in the centre; this may be quite small—a mere papule—or of large size. An eruption of this kind has occurred in a child at the breast, whose mother was taking the medicine and who was not herself affected (*Lancet*, ii., 1874, p. 657). A more rare, but still recognized form, is that of erythematous patches, which may be local or general (Veiel: *Medical Times*, ii., 1874, p. 152; i., 1878, p. 151).

Synergists.—The sedative action of the alkaline bromides on the nervous system is assisted or modified favorably under certain conditions by chloral, cannabis, and opium; their regulating effect upon vaso-motor nerves, especially by quinine; their depressant effect upon the circulation is aided by aconite, gelseminum, veratrum viride, and digitalis, also by nitrate of potash and allied salts; their alterative power is increased by cod-liver oil, iodides, and alkalies, though iodides would interfere with sedative action.

Antagonists.—True stimulants, such as alcohol, ether, and coffee, which tend to induce arterial congestions, oppose the action of bromides; thebaine and narcotine, strychnia, and nicotine, are also antidotal. Strychnia especially has an opposite effect on the cord and medulla oblongata, though without a direct action on the brain or the muscles. The difference in the capillaries of the spinal centres post-mortem, after using the two drugs, was especially noted by Saison; under bromide the vessels were scarcely visible, under strychnia intensely congested.

Atropia antagonizes in some degree bromal hydrate (Hughes Bennett: *British Medical Journal*, i., 1875), and ergot is opposed, in its full action, to bromides—although any of the above-named drugs may at times be usefully combined with them, and made to modify their ordinary action for certain therapeutical results. This is evidenced by clinical experience.

Dr. Bill argues that chloride of sodium is antagonistic to bromide of potassium, and that the latter remains longer in the system if the former salt be avoided (*American Journal*, 1868).

The value of arsenic in curing and preventing bromide rash has been asserted by several observers, and lately Dr. Gowers has published illustrative cases (*Lancet*, i., 1878).

Therapeutical Action (External).—*Morbid Growths, etc.*—Bromide of potassium, applied in fine powder to indolent ulcerations and morbid growths with raw surface, is said to act well and painlessly as an alterative or caustic. An epithelioma has been successfully treated in this manner (Perrant: *Medical Times*, ii., 1876, p. 368).

Mixed with simple ointment (1 part in 5), or with glycerin, it forms a

sedative, somewhat astringent application for painful and sloughing ulcers, also for painful conditions of mucous membrane, hæmorrhoids, and anal fissure, and for chronic eczema and acne.

A lotion containing 1 part to 50 of water is said to restrain hemorrhage (*Lancet*, ii., 1876, p. 474).

THERAPEUTICAL ACTION (INTERNAL).—In 1826, Barthez, Andral, and some few other (French) observers, ascertained that the bromide of potassium could relieve arthritic pain, and Pourché found it useful in bronchocele. Dr. Robert Williams (of St. Thomas' Hospital) reported such success with it in the treatment of enlarged spleen, as to contribute to its introduction into the London Pharmacopœia of 1835, and yet it is instructive to remark, that so little clinical evidence of its value was obtained by others, that the medicine was omitted in that of 1851. Puche, however, found it to cause partial anæsthesia; and Thielman, a Russian physician, noted its sedative influence on the generative system; and from these suggestions Sir Charles Locock was led to use it in epileptic or epileptiform attacks, connected especially with ovarian or uterine excitement, and the mention of his successful results at the Medico-Chirurgical Society in 1857 was practically the commencement of general knowledge upon the subject.

Epilepsy.—For this malady the bromides are now, by common consent, held to be the most generally reliable remedies. They give the best results in *sthenic* cases of uncertain causation, when convulsive attacks are very violent, but have not become chronic. Attacks connected with tumor, or injury, or organic lesion, are also more or less relieved, probably in proportion to the amount of *hyperæmia* present. Dr. Wilks found better results from bromides in *traumatic* cases than in any other (*Medical Times*, ii., 1861, p. 635), and Dr. Broadbent noticed the same fact (*Lancet*, i., 1866, p. 92). Where there is *excentric* irritation, as in the generative system or the abdominal organs, benefit is almost always obtained, and Dr. Bill has compared the action of bromides in such cases to that of a ligature, interrupting communication between an impression or "aura," and the brain; they seem to diminish not only conductive, but reflex function. In a case in my own practice, where a large uterine fibroid produced alarming epileptiform symptoms, opium invariably increased the spasms, but bromides relieved quickly.

Minor forms of epilepsy, as "petit mal," evidenced by transient vertigo or loss of consciousness, with perhaps some spasm, but not true convulsion, are not so certainly relieved; and when the epileptic attacks occur only, or chiefly, at *night*, and at *long intervals*, bromides are not always the best remedies; also in very chronic cases of many years' duration, they can usually do little more than modify the character of the attacks. When the patient has become nerveless and stupid, belladonna has the advantage over bromides, and when there is marked anæmia or

profound depression, they are not desirable. Nux vomica, or strychnia, in small doses, will act better, especially if consciousness be not completely lost during the fits. It must be noted, however, that according to statistics recently published by Dr. A. Hughes Bennett, all varieties of the disorder—petit mal, nocturnal or chronic epilepsy—have shown good results in large proportion under bromide treatment (*Edinburgh Medical Journal*, February 7, 1881).

Supposing the case be one suitable for this, it is important for success that it should be carried out thoroughly, in sufficient doses, and continued sufficiently long. It must not be interrupted as useless in any case, unless distinct evidence of its physiological effect has been obtained without relief to the symptoms. The production of drowsiness, or of a characteristic skin-eruption, may be taken as some guide, but a better one will be found in the degree of insensibility produced in the fauces; if no irritation or retching is caused by touching the uvula or pharynx, then probably the patient is under bromic influence. From 10 to 40 gr. thrice daily is an average limit, more being given at night-time, if necessary. At first, even larger quantities may be required, and many instances of success from very large doses are on record. Puche and other French physicians have given 100 and 200 gr., but not without some vomiting and prostration (*Medical Times*, i., 1874). Dr. Squibb found 60 gr. act well when less failed; and he notes that, if the medicine needs to be omitted for a time, it should be resumed at the full dose again. Dr. Farquharson gave 30 gr. four times daily with benefit, to a child aged five; and Dr. F. Beach, at the Clapton Asylum, commonly gives 15 gr. every two hours for a time, and 1 or 2 dr. during a paroxysm (*British Medical Journal*, ii., 1877). Thirty grains thrice daily have been taken for twelve years, and although before treatment the patient was incapable of work, he became equal to the conduct of an ordinary business (*ibid*, p. 655). There was no effect on the sexual power. I have often myself given similar large doses, and for a long period; but there is no *one* rule to follow, as I have found 10 gr. act as effectively in some cases as 60 gr. in others. Sometimes 5 gr. will cause troublesome acne.

When the attacks are once controlled, a single daily dose of from 20 to 60 gr. will usually suffice to keep up the effect, and may have to be continued for many months or years. Bromide, indeed, has been well called the "food of the epileptic," and sometimes needs to be taken as regularly as food; still, an occasional intermission—one or two days in a week or fortnight—is usually desirable, for thus the effect of the medicine is better preserved, with less injury to the patient. It is necessary to watch carefully its effect on the general health, and to omit it, or at least to lessen the dose, if the skin should be much affected, the extremities become cold, or anæmia, prostration, or diminished sexual power be traced to it. In exceptional cases there has been developed, under bromides,

a peculiar general irritability of asthenic character, or even an excited condition resembling mania (Sequin, Voisin). Minor symptoms, such as headache, "stuffiness" of head, lachrymation, and gastric irritation, have been connected with the use of a preparation adulterated with *iodide* (Legrand du Saulle: *Medical Times*, i., 1872, p. 319). If during the omission of treatment convulsion threatens to return, bromide should be at once resumed, but perhaps in a different combination.

For weakness or anæmia, quinine or iron may be added with advantage. Strong coffee hinders development of bromism (Echeverria), and arsenic in small doses will prevent or cure bromic acne. The addition of a small quantity of strychnia to the bromide is recommended by Brown-Séquard and by Tyrrell (*Medical Times*, i., 1871, p. 36); it certainly should be only in small doses, or it would antagonize the bromide. Nux vomica, in my opinion, holds but a doubtful place in the treatment of epilepsy; it will improve digestion, and give "tone" to a relaxed nerve-system, and relieve convulsive attacks when consciousness is not wholly lost, but in such cases it acts better alone than with bromides.

Several alkaline bromides taken together sometimes act better than any single one (Brown-Séquard), and I have often found advantage from combining the potassium and ammonium salt. General experience has not yet corroborated the observations of Weir Mitchell as to the superior efficacy of the lithium salt, nor of Hammond as to the bromide of calcium, but they may be useful as alternatives. The bromide of sodium is less depressing to the heart than that of potassium, as has been illustrated by Dr. Hollis (*Practitioner*, 1878).

I cannot speak well of the addition of belladonna, often recommended. That medicine has its own field in cases rather acute in character, difficult to diagnose, but on the border-land between epilepsy and eclampsia. It is especially useful when they are traced to sudden fright, and are attended with congestive headache between the attacks, and again in the eclampsia of robust plethoric children with cerebral congestion; but, when given in combination with bromides, I have found its action unreliable and confusing. Dr. Beaman combined lactucarium and lupulin (*Lancet*, ii., 1867), and the addition of digitalis has been found valuable (*Lancet*, ii., 1871, p. 705). I have myself seen excellent results from the last-mentioned in conjunction with bromides, in epilepsy connected with masturbation or nocturnal emissions; it has marked control over such conditions.

I find it best to give the digitalis separately, morning and afternoon, and the bromide at night, and have found this treatment stop the onanism and emissions, and cure the epilepsy. The infusion of digitalis is the best preparation, and should be given in ½ to 1 dr. doses.

Charcot recommends the bromide of zinc (*British Medical Journal*, ii., 1877, p. 132), and Bourneville the bromide of camphor (i., 1877). I

have frequently tried the latter compound, but have never seen from it results which could not be better obtained from other bromides, or from camphor separately. Beigel recorded good results from bromide with morphia hypodermically (*Medical Times*, i., 1869, p. 68), but morphia, when given internally for any length of time, acts injuriously, and when subcutaneously administered for a similar time is still more detrimental.

I am satisfied, from careful and long-continued observation, that opium does not, in any form or combination, cure epilepsy; but when convulsive attacks occur as complications of passing mental disease, it is sometimes helpful, either alone or combined with bromides, for allaying excitement and convulsion for a time, and procuring sleep, but its effects are transient.

The proportion of *cures* obtained by bromides or their combinations—meaning a cessation of convulsive attacks for from six months to four years or upwards, according to the period that cases remained under observation—has been stated at about *one-half* for adults, and one-quarter for children (Voisin, Legrand du Saulle); and even if *absolute* cure be not obtained quite in such proportion, it is so sufficiently often to prove its possibility. Probably, however, in the majority of cases, freedom from attack will be contingent upon more or less continued use of the remedy. In cases that are satisfactory, we see nothing of an effect sometimes mentioned as an objection to the use of bromides, viz., a greater violence of the attacks as they become less frequent. It is true that this occurs sometimes during the natural course of the malady, but it cannot be directly connected with the medicine; on the contrary, this, as a rule, diminishes the severity as well as the frequency of the convulsion.

Binz has suggested that not only the physiological, but also the therapeutical effect of the bromide of potassium is due to the latter agent (potassium), improving the blood-condition, etc. (*Practitioner*, 1874), and Sanders even states that the *chloride* of potassium has answered equally well in his hands (*Centralblatt für Medicin*, 1868); but, while we agree that some of the depressant effects of bromide of potassium in the circulation might be explained by the known action of potash, its effects on the nervous system cannot be so, and the result of Sequin's observations showed that the use of chloride of potassium *increased* the attacks in cases which bromide *relieved* in the proportion of 80 per cent. (*Medical Times*, i., 1878). The nitrate and bicarbonate of potash have also been proved useless (Anstie: *Practitioner*, 1874).

In the "Gulstonian Lectures for 1880," Dr. Gowers, stating the results of his experience in the treatment of epilepsy, says that when small doses of the bromide are given to ward off regularly recurring attacks, they should be taken only a short time—two or three hours—before the fits are expected; that they will fail if taken at longer intervals before. Larger doses may, however, be taken then. He has met with many cases

in which he has noticed a cumulative effect of the drug, but many others in which, after a time, a tolerance of it, or indifference to it, is attained, and an increase of the dose becomes necessary to obtain the customary result. To *control* the fits the bromide must be given frequently, but not in larger doses than a drachm or a drachm and a half in the day; but, for the *cure* of the disease, he considers it necessary to keep the patient for a time under the full influence of the drug, by giving a large dose every two or three days—as much as can be well borne. Gowers has given, in this way, as much as an ounce at a time, but adds the caution not to begin with a larger dose than half that quantity. He considers that only in this way can the "stability of the resistance of the nerve-cells" be re-established. The drugs that he has found most useful in combination with bromide, where that by itself has failed, are digitalis (where there is associated cardiac disturbance, or in nocturnal epilepsy), belladonna, cannabis indica (when between the attacks there is persistent headache), and iron.

Convulsion.—In the wide range of convulsive and spasmodic disorders, *outside* that which we distinguish as epilepsy, bromides are very efficacious. In the convulsions occurring during *pregnancy*, especially from reflex irritation at the time of parturition, they are more distinctly indicated than in the albuminuric form, but I have seen them also relieve the latter. Peaslee thought them valuable only during the threatening stage, when the urine is scanty, and certainly, the earlier the patients are brought under their influence, the more satisfactory the result. In *uræmic convulsion* some observers have objected to the use of bromides, but they have been found generally of some assistance in lessening the paroxysm; eliminant and other remedies should be conjoined. The dose in such cases should be large, ½ dr. every hour or two. When swallowing is impossible, they act well given in enemata (Gimbert and others: *Medical Times*, i., 1872, and i., 1874).

Dentition.—In the restlessness and nerve-irritation or convulsion sometimes attendant on dentition, bromides are exceedingly useful, "so that the gum-lancet is scarcely ever needed." The convulsions even of meningitis I have frequently seen arrested by the bromides.

Tetanus—Strychnia-poisoning.—We have shown reason to believe that bromides lessen spinal congestion and diminish reflex irritability (*v.* p. 113), and this being so, they ought to prove valuable remedies in the disorders named. We have not a large amount of clinical experience on this point. In a recent collection of 415 cases of tetanus, by Dr. Yandell, bromide does not seem to have been used once (*Brain*, October, 1878), but Dr. H. C. Wood has tabulated 18 cases of tetanus thus treated, and of these only 2 died; in one of them, large doses of belladonna confused the result. In most of the successful cases, chloral or morphia was given at bedtime.

Dr. Southey relates a successful case, in which conium was combined (*Lancet*, i., 1875). Of the bromides, full doses—at least ½ oz. in the twenty-four hours—should be given.

Saison found with animals that hypodermic injections of strychnia distinctly modified the action of bromide, and *vice versa;* and there are a few instances in which a fatal result from poisoning was, in all probability, prevented by bromide treatment. Thus, Dr. Gillespie records a case in which nearly 3 gr. of the alkaloid were taken, and very serious symptoms developed; but recovery took place under the influence of an ounce of bromide given in divided doses—no vomiting occurred (*American Journal*, October, 1870). In Dr. Hewlet's case more than 4 gr. of strychnia were taken, and although vomiting had occurred and opium been given, severe convulsions had set in; 90 gr. of bromide were administered, at first every half-hour, and afterward 60 gr. every hour, and twenty-six hours after the first dose the patient could walk (*British and Foreign Review*, July, 1871). Another case of recovery after a 3-gr. dose of the poison, and similar treatment, is given by Dr. Bard (*Philadelphia Medical Times*, June, 1871; *Record*, 1879).

Migraine, Congestive Headache, etc.—If given in the prodromal stage of an attack of migraine, the bromides often succeed in preventing its development, and especially when the head-pain and the nerve-disturbance *precede*, or are more prominent than the nausea or gastric disorder (Yandell, Latham). Five grains every hour or half-hour may be given, but if an attack *has already set in*, a full dose of 20 to 30 gr. is better, and if this produces sleep, the patient usually wakes free from headache. After the paroxysm has *fully* set in, the remedy does not seem to control it (*Medical Times*, i., 1875, p. 338).

In ordinary congestive headache, with flushed face, and intolerance of light and noise, and in congestive neuralgia generally, the bromides are serviceable; also in the headache occurring in delicate children from even moderate application to study. Dr. Day recommends their use with iodides for children who suffer from constant headache and debility (*Lancet*, i., 1875, p. 854); but I have been disappointed with this combination under such circumstances.

Chorea.—The varying results obtained in the treatment of chorea must be connected with its varying pathology, which is not yet well understood. I have seen a few patients recover rapidly under treatment by bromide, but the majority are too anæmic or asthenic to bear it well; hence, it is not surprising that Dr. R. Reynolds found it even prejudicial in some cases.

Dr. Ramskill tried fully the potassium salt, "and with strong prejudice in its favor," but without satisfactory result. Camphor bromide is said to have acted better (*British Medical Journal*, i., 1877), but has not done so in my experience.

Hysteria.—In ordinary cases of hysteria, bromides alone do not give the relief that might be expected. The convulsive epileptiform seizures which sometimes occur may be controlled by them when the patients are fairly strong, but mere emotional disturbance and nerve-debility are better treated by other remedies. The malady is essentially connected with enfeebled nerve-power. Gubler, indeed, compares its paroxysms to convulsions after hemorrhage, and in such cases bromides are not really curative. In *combination*, *e.g.*, with iron, valerian, or camphor, they may be of more service.

Uterine Irritation.—If hysterical symptoms be definitely connected with ovarian irritation or uterine congestion, then the bromides are more distinctly indicated. In the distressing condition of unrest, undue apprehension and depression, which often occurs at the climacteric period, they may prove of the greatest service, quieting the restlessness, and relieving the sense of fulness in the head and flushing of the face. Dr. Ringer found them to exert a favorable influence over the apprehensive and desponding thoughts which arise sometimes in the later periods of pregnancy (*Lancet*, i., 1869), and they have relieved even the sensations and symptoms of a "spurious pregnancy" occurring at the climacteric period (Simpson: *Medical Times*, ii., 1859).

Spasmodic Disorders—Laryngismus.—The bromides, but especially the bromide of ammonium, will be found very useful in relieving the laryngeal spasm of this disease; but its usual connection with rachitis must not be overlooked, and tonic treatment, good hygiene, and improved nutrition must be combined for a satisfactory result.

Pertussis.—Dr. Gibb was one of the first to ascertain the value of bromides in this disorder, and he found the ammonium salt to act best; it quickly relieved the whoop, *i.e.*, the laryngeal spasm. Dr. G. Harley also early recorded satisfactory cases (*Lancet*, i. and ii., 1863). I have often verified this use of the bromides, especially in early stages. I order for children 3 to 5 gr. every two to four hours, as a rule not giving more than 20 gr. in the day, because of the depression induced in weakly subjects; I often combine belladonna, and sometimes chloral, with the treatment. Dr. Ringer reports them as useful only in simple, uncomplicated cases, but neither dentition nor a pyrexial state need prevent their use if the spasm continue; they are fairly presumed to lessen congestion in the medulla as well as in the mucous membrane of the fauces, and to diminish reflex excitability.

If catarrh be present, an expectorant may be conjoined, and if bronchitis or pneumonia supervene, the spasm generally subsides for a time, and a different treatment is indicated. The convulsion of pertussis I have frequently seen relieved by bromide, but belladonna is much more serviceable.

Dysphagia.—There is a peculiar form of difficulty in swallowing

liquids, which I have seen only in children; they drink readily, but the fluid either returns at once from the mouth or partly chokes them, or they remain, with open mouth, gradually swallowing small quantities with continued muscular spasm. No definite cause can be assigned. The symptoms come on a few months after birth, and I have seen it mostly among the children of the poor. It may be relieved by bromide, and Dr. Ringer has remarked that a similar condition, when congenital, is much benefited by bromide of potassium.

The dysphagia of phthisis, connected with local irritation and inflammation, is also relieved by the salt, which should be swallowed slowly and well diluted with mucilage.

Colic.—In cases of cramping pain in the stomach or intestine, such as occurs more frequently in children, and is independent of diarrhœa, but connected with irregular muscular contraction, the bromides usually relieve better than other remedies.

Spasm of Rectum and Bladder.—In cases of tenesmus, whether of the bladder or rectum, bromides will often be found useful. Hammond recommends bromide of camphor (*British Medical Journal*, i., 1877), and ½-dr. doses of bromide of potassium have given relief to a severe case of rectal spasm when opium, belladonna, and instrumental interference all had failed (*Lancet*, ii., 1873, p. 456).

Enuresis.—In the simple enuresis of children, bromides may usually be relied upon. The good derived from them is probably due to "increasing the stability of resistance of the cells in the lower part of the spinal cord" (Gowers).

Spasmodic Asthma.—There are certain cases in which very striking results may be obtained from the bromides: *e.g.*, a man, aged thirty, subject to attacks since infancy, suffered about once in the week from evening till two or three o'clock the following morning, but, after a fortnight's treatment with full doses of bromide taken at night, he had no further attacks (Saison). As a rule, it will be found that this remedy does not act so well as an "antispasmodic" *during* the *paroxysm*, but better if given during the *interval*, apparently by exerting a sedative influence on the central nervous system.

Dr. Begbie found it very successful in two cases (*Edinburgh Medical Journal*, 1866), and G. Sée reported that though the catarrhal element in the malady was not modified, the access of paroxysms was delayed, and the dyspnœa lessened or quite controlled (*Bulletin*, 1865). I can recommend the bromide in chronic cases of asthma, and especially when there is excentric irritation, as of the pelvic organs; it is sometimes well combined with iodide.

Angina Pectoris—Palpitation.—The bromide is sometimes of service in severe breast-pang. Thus, Papillaud relieved severe paroxysmal attacks by the use of ½ to 2 dr. doses continued "at intervals" for two or

three months. In nervous palpitation it is often a very good remedy, and I have known it especially relieve gouty patients. Berger found bromide of camphor to answer well.

Vagus Irritation.—Dr. Somerville has related a remarkable case in which a very slow pulse of fifteen to twenty per minute was found on one occasion after an error in diet, and seemed, therefore, connected with irritation of the gastric terminals of the vagus; the slowing was succeeded by quick, tumultuous heart-action, and during this stage marked benefit was derived from bromide (*Practitioner*, March, 1876). It was, however, given with belladonna.

Undue Reflex Action, Vomiting, etc.—In a number of cases, somewhat dissimilar in symptoms, but connected with exaggerated reflex action, whether spasmodic in character or exhibiting altered function or secretion, the bromides prove useful. In reflex vomiting, as that of pregnancy, or even in sea-sickness, and sometimes in cerebral vomiting, they give relief. Five to ten grain doses, if retained, are often sufficient; but, in obstinate cases connected with pregnancy, ½ to 2 dr. doses have been successfully given by injection (*Lancet*, i., 1874, p. 770). Laborde has seen it useful in the vomiting of various gastro-intestinal disorders.

Diarrhœa.—When this is reflex in character, as it often is during dentition, or when associated with a congested relaxed state of intestinal mucous membrane, bromides may prove the best remedies.

Cholera.—It is not going beyond our knowledge to state that capillary spasm and congestion of vaso-motor centres are essential elements in the phenomena of cholera, and it would not, *à priori*, seem unreasonable to expect benefit from bromides; there is certainly some clinical evidence of it. Thus, Dr. James Begbie, giving ½-dr. doses of the potassium salt, noticed that capillary circulation was quickly re-established, as shown by the return of color to the limbs, and the recurrence of urinary secretion that had ceased: he considered the remedy a valuable one (*Edinburgh Medical Journal*, and *Lancet*, ii., 1866). Dr. Henry Sutton has also published cases of recovery under its use (*Medical Times*, ii., 1867).

Menorrhagia—Leucorrhœa.—Bromides often act very well in relieving both of these discharges, but especially the former when dependent on congestion.

Spermatorrhœa, etc.—In irritation of the male genitals in plethoric subjects, with undue erections or excessive seminal losses, the bromides are often highly useful. They have a local anæsthetic effect when applied to the urethra, and when taken internally their value is evident rather in cases when sexual excitement is connected with local irritation and congestion, as hæmorrhoids, ascarides, etc., than when there is mental or central causation. They tend to lessen, also, spinal congestion and reflex irritation. Berger finds, perhaps, the best results from camphor bromide in such cases (*Medical Times*, i., 1877, p. 264). When there is

marked debility with anæmia, or when spermatorrhœa is unaccompanied by erections or sensations, bromides are not the best remedies.

Cystitis—Urethritis.—Saison has seen the bromides give great relief in these cases. They should be used both locally and internally.

Disorders of Sympathetic Nerve.—A number of anomalous symptoms which may be referred to this cause are relieved by bromides; for instance, "sudden numbness, coldness, deadness, or pricking sensations in one or more limbs; distressing, indefinable feelings in the epigastrium or abdomen; or sensations akin to rigor, with much anxiety and palpitation or 'fluttering' of the heart." In such cases the local circulation may be interfered with, the pulse in one arm becoming irregular and faltering, while in the other it may remain unaltered, and the heart-beats continue normal.

Urticaria.—In the capillary congestion of this malady, which is connected with irregular action or paresis of vaso-motor nerves, the bromides are indicated. Thus, Dr. Andrews reports the cure of a chronic recurrent case under their use (*Lancet*, i., 1870, p. 402).

Exophthalmic Goître.—According to Dr. Brown (U. S.) and others, the bromides have proved useful in this malady (*British and Foreign Review*, i., 1868), and I think benefit may usually be expected from them, especially when combined with quinine.

Phthisis Pulmonalis.—There are certain distressing phthisical symptoms which are amenable to the influence of bromides on vaso-motor nerves and reflex action. Thus, a hacking, laryngeal cough, or reflex vomiting, or even pyrexia, may be relieved; also the difficulty and pain in deglutition connected with pharyngeal irritation. Profuse sweating and even flux from the bowels may be controlled by the bromides—especially by bromide of calcium—though usually the anæmic and depressed condition may be met better by acids or mineral astringents.

Insomnia is but a symptom, and one produced by various and often opposite pathological conditions. We accordingly find that the different hypnotics cannot be used with equal success in all cases presenting this one symptom in common, and so, while bromides are of most signal value in some conditions, they are useless or even harmful in others. This may be explained partly by varying conditions of the blood-supply, partly by difference in the states of nutrition of the nerve-cells. It is when there is *moderate cerebral hyperæmia*, such as probably exists after prolonged mental effort—whether associated with study, with excitement, or anxiety—and when unrest and sleeplessness are marked symptoms, that the bromides are far more soothing and more curative than opium; and even if inflammatory action be present, they may still be very serviceable, in conjunction with aconite, ice, or other remedies.

If there be much cerebral *anæmia*, it may even be increased by the remedy, and I have seen, in debilitated hypochondriacs, and in some

aged people, aggravation of the symptoms with marked increase of the prostration. In some cases of senile insomnia, I have, however, found it very useful given with the last meal, in doses of 10 to 20 gr. or more, dissolved in milk, tea, soup, beer, or cold water. In the sleeplessness of convalescence from acute disease and of dyspepsia, bromide is useful, combined in the latter case with dietetic and other special treatment. In pregnancy, where pain is suffered and prevents sleep, a combination of chloral and bromide—15 gr. of each—is especially useful. In weakly subjects, and especially in the insane or hypochondriacal, bromide is best given in combination with cannabis indica. When insomnia is induced by severe pain, opium is the best remedy; but its effect is heightened, and its tendency to produce headache, faintness, and nausea lessened, by bromide. Da Costa recommends the latter to be given in full doses half an hour before, and two hours after, the opium.

To choose a suitable quantity is of importance; it is usually from 20 to 30 gr.

Wolfe relates a case of insomnia with hypochondriasis and irritability, from over-anxiety, when 5 gr. proved useless, but ½ dr. "acted like a charm." Behrend relates two very good illustrations of nervous excitement and anxiety, with loss of sleep, in which 25 gr., at first thrice daily, afterward less often, proved quickly curative (*Lancet*, i., 1866; ii., 1864, p. 1). In the sleeplessness and delirium of fevers, the bromides exert a favorable influence in procuring sleep, and they prove a valuable resource when opium is not admissible.

I have sometimes found bromide of camphor, in 3 to 5 gr. doses, procure sleep for hysterical subjects, and Deboul recommends it in the unrest of cardiac disease, and of phthisis (*British and Foreign Review*, i., 1865). The solid capsule of Clin is liable to cause gastric irritation, and is better given dissolved in milk.

Delirium Tremens.—For the excitement, wakefulness, fright, and tremor which follow the abuse of alcohol, and which commonly precede a fully developed attack of delirium, large doses of bromide often prove of great use, either with or without opium. I have known them prevent the further development of the attack; in later stages they have not the same power, but bromides have acted well combined with chloral. To this statement I must, however, add a caution as to the use of full doses of the latter remedy in delirium tremens, for I am cognizant of more than one case of sudden death traceable to it, in all probability.

Gubler has written specially on the value of bromides in amblyopia and alcoholic amaurosis.

Night-terrors—"Nightmare."—Children especially are liable to attacks of terror in the night, when they awake screaming, and are so deeply impressed by some imagination or dream, that they are, at first, scarcely conscious. This condition is connected with a reflex irritation of the

nervous system, and is much under the control of a night-dose of bromide. The nightmare of adults may also be relieved by it; aperients should not be neglected in such cases.

Mania.—The use of bromides in insane patients requires special study and care, because of their liability to be suddenly depressed, and the prostration I have sometimes seen well illustrates the clinical fact that an enfeebled, ill-nourished nervous system often contra-indicates these medicines, even if the general bodily health seems to be fair.

Dr. S. W. D. Williams records that, of thrity-seven insane epileptics treated by bromides, the fits were relieved in most, but great depression occurred in some of them without any relief to their attacks; ½-dr. doses proved too large; catharsis was caused in two cases, and possibly the rapid development of phthisis in a third (*Medical Times*, ii., 1864, p. 88).

Mr. Wood (Durham) has also recorded instances among insane patients of "sudden development of severe prostration and despondency (*British Medical Journal*, ii., 1871); vomiting and abdominal pain were also caused.

Dr. Clouston, in a careful study of the effects of different medicines upon the nerve-condition of lunatics, found that the bromides, if given alone, needed to be used in very large doses for the subduing of violent paroxysms. One female patient took 7 oz. in divided doses, but then suddenly lapsed into a condition of extreme "torpid depression," not free from danger to life, and continuing many days. The same physician ascertained that a combination with cannabis indica gave, even in small doses, much better results than either remedy alone, ½ dr. of each given together acting as a hypnotic better than 1 dr. of tincture of cannabis indica, or 2 dr. of bromide (*Medico-Chirurgical Review*, ii., 1870, and 1871).

Puerperal Mania.—In acute stages of excitement and delirium connected with the puerperal state, bromides act well, and should always be given. They have, doubtless, an influence over the uterine and ovarian congestion of that state, and over reflex irritability, and many successful cases of use are on record. Curgenven has found the potassium salt act quickly and well when given by the rectum. I have often given it alternately with aconite, with much advantage.

Erotomania—Nymphomania.—When these conditions occur in connection with a generally demented state, the bromides do not seem to relieve so much as might have been expected. My friend, Dr. Maekey, when in charge of a large asylum at the time when bromides were first introduced, and were specially recommended in sexual cases, gave the potassium salt to many of the younger patients, especially youths addicted to masturbation, but generally with the result of inducing extreme and miserable depression, without controlling the symptoms. Dr. Williams also noted that in his thirty-seven insane cases the sexual system was not at all, or but slightly affected. Even in subjects of average mental health,

but addicted to onanism, the bromides, though they lessened the venereal appetite for a time, effected no cure in Dr. Bill's experience, and he concluded that they could lessen only *excentric* sexual irritation (*American Journal*, July, 1868). In this they certainly are highly valuable. In the few cases that I have seen approaching to nymphomania, benefit was derived from the bromides alone, but they act best when given in conjunction with bath, counter-irritation, and moral agencies. Dr. E. C. Clarke and Dr. Begbie have recorded very satisfactory results.

Cerebral Apoplexy.—There is reason to hope for advantage from the use of bromides in the symptoms of cerebral congestion which point to an apoplectic tendency. Dr. Bastian has remarked that, in such cases, when the heart-action is forcible and frequent, these remedies, conjoined with aconite, are very suitable, and I quite concur in this statement (*Lancet*, ii., 1874, p. 897).

Meningitis—Hydrocephalus.—I have seen the convulsions of traumatic meningitis arrested under bromide of potassium, and it is said that recovery from tubercular meningitis (acute hydrocephalus) has followed its use. In support of this statement Dr. John Brunton has recorded four cases (*Glasgow Medical Journal*, 1873), in which the heads were enlarged, and the symptoms were certainly serious, but there were no convulsions, and the diagnosis must be held rather doubtful (cf. pp. 87, 88).

Spinal Congestion—Cerebro-spinal Meningitis.—In spinal congestion of acute character, with pain, hyperæsthesia, cramp, and spasm, the bromides have proved so far useful as to merit always a fair trial.

In true cerebro-spinal meningitis—though a very fatal disease under any treatment—I have seen great advantage from bromides, but like all depressant remedies they must be used with caution, for there is liability to sudden failure of the circulation from conditions of the disease itself. Subject to the same caution, I think it desirable to conjoin aconite or belladonna throughout the treatment.

Diphtheria.—The bromides have proved valuable in this disorder, both when taken internally and when applied to the inflamed parts. Dr. Caro uses a spray containing 1 dr. to the ounce, and finds it lessen capillary congestion, and when the cough is dry it aids the expectoration of membrane (*Medical Times*, i., 1874, and i., 1876, p. 588). Dr. Post recommends a solution of the same strength with 20 min. of bromine, and gives 10 drops every hour to a child of three years.

Rheumatism.—The bromide of ammonium has been found extremely useful in acute rheumatism by Da Costa (*American Journal*, April, 1871). Guéneau de Mussy also praises the bromide for the same malady. For subacute cases, for rheumatic gout, and for the resulting stiffness and nodosity of joints, the bromide of lithium is recommended (Bartholow). This remedy is certainly valuable for relieving the wakefulness

and delirium of rheumatic fever; morphia may occasionally be well combined with it.

Bronchocele—Splenic and Glandular Enlargements.—The great value of bromides in nerve-disorder has led us, perhaps, to think less of them as remedies in scrofulosis and glandular enlargements, but they are often very useful in such conditions. Dr. Wilks recorded their good effect in bronchocele (*Medical Times*, ii., 1861, p. 635), and I have used them frequently and successfully in gland-swellings connected with struma. They have been by others recommended in combination with liquor potassæ (*Lancet*, i., 1860, p. 62). The bromo-iodine waters of Kreuznach and Woodhall Spa are also good forms for their administration.

Dr. Robert Williams found the bromide of potassium extremely useful in reducing enlargement of the spleen (malarial), and, in an appendix to his classic work on Morbid Poisons, gives several striking instances of its value when other and better known medicines had failed.

Mr. Spencer Wells has confirmed the observations of Dr. Williams, and, amongst other cases, has recorded that of a child, aged eight, extremely emaciated, suffering from hectic, and with the abdomen distended by an enormously large spleen, the lower edge of which extended to the pubes. The case seemed apparently beyond the power of medicine, but yet, under the influence of 3 gr. of bromide thrice daily, some diminution was produced within a week; under 5 gr. this continued, until at the end of a few weeks the viscus was above the umbilicus, and the child convalescent. The case was either connected with ague or with blood-poisoning from unhealthy atmosphere, and is a very remarkable one. Acting on the suggestion of Mr. Spencer Wells, I have myself used the drug in similar cases, but in larger doses, and have been pleased with it. Claude Bernard has recorded equally good results, but with doses of 20 to 40 gr. daily (*Bulletin*, 1874).

Enlarged Tonsils.—Saison has seen the bromides of service in this condition, and in the recurrent angina connected with it.

Fibroid Tumors.—The power which bromides possess of stimulating absorption led to their use in cases of uterine fibroid, and Simpson recorded successful results (*Medical Times*, ii., 1859, p. 599), also Graily Hewitt (*Medical Times*, i., 1861).

The Kreuznach waters, which contain bromides and iodides, have long enjoyed a special reputation in such cases; but, if we are to judge by a discussion of some years ago, many eminent authorities in London have seen little or no advantage from them (*Medical Times*, i., 1857). My own experience, however, and personal observations made at Kreuznach, have satisfied me that a course of these waters *does* often diminish the congestion and the fibroid growths, although their good effects probably are not *wholly* due to their containing bromides and iodides. In many of my cases the waters have also removed or reduced dense infiltrated

deposits around the growths, and have given much relief and comfort to the patient (*v.* p. 166).

Ovarian Tumor.—The Kreuznach waters acted so favorably upon several of my patients with unilocular ovarian cysts, that I now always recommend one or two courses of them before advising an operation. Bromides given in 5 to 20-gr. doses two or three times daily, and continued for months, frequently diminish the size of the cyst, and improve the general health. The dose should be varied from time to time, according to circumstances.

Absorptive Effects of Bromides.—There are other growths and deposits in which these effects have been utilized by different observers, but not extensively. Dr. Wilks observed benefit from the bromide of potassium in cases of cephalalgia dependent on thickened membrane or thickened bone (*Lancet*, i., 1870, p. 191); Dr. Brown, in acute and chronic inflammation of testes and chronic inflammatory enlargements (*British and Foreign Review*, i., 1868); and Dr. Bird states that from ample experience in Australia, where hydatids are common, the continued administration of bromides has the power of destroying the parasites, and causing absorption of the cysts (*Medical Times*, ii., 1873, p. 164). (For a similar effect of iodide, *v.* p. 87.)

Preparation and Dose.—*Potassii Bromidum:* dose, 5 to 20 gr. and upwards (*v.* pp. 106, 107, 109). *Ammonii Bromidum:* dose, 2 to 20 gr. and upwards.

Concerning the different bromides, we may here briefly state that the *potassium salt* is in the most common use, but contains the least bromide of the alkaline salts (*v.* pp. 97, 98), and is more depressing to the circulation.

The *sodium salt* I consider rather more powerful as a bromide, though all observers are not agreed on this point. It is less depressing, and is more easily assimilated (Clymer: *Medical Times*, i., 1872, p. 238).

The *ammonium salt* possesses some of the stimulant characters of its base, which is liberated by decomposition. Its action is said to be more rapid, but also more evanescent (Begbie). The *lithium salt* has been found to relieve some epileptics better, and in smaller doses than the potassium salt, and to give sleep well (Gibb, 1864; Weir Mitchell: *American Journal*, ii., 1870). The *calcium salt* is said to be more active than that of potassium, 22 gr. of the former causing sleep when the latter failed (Hammond). The *compound with camphor* (monobromated camphor) reduces heart-action and lowers respiration and temperature like the other alkaline bromides; it is efficient as a sedative in less dose—3 to 6 gr. In the *compounds with morphia and quinine*, Dr. Richardson expects to secure the sedative and tonic effects of these drugs without the unpleasant cerebral symptoms which sometimes accompany them (*Medical Times*, i., 1871, p. 413). I have found them useful. *Bromhydric acid*

is said to produce most of the good effects of alkaline bromides with less depression, and to be more readily borne (C. Wade, M. Fothergill). Its real value is, however, not yet proved.

CHLORUM—CHLORINE, Cl=35·5.

Chlorine, discovered by Scheele in 1774, is a greenish gas, irrespirable, and when incautiously inhaled producing injurious irritant effects. It has a peculiar odor; is very soluble in cold water; it bleaches all vegetable colors, and is a powerful disinfectant; under a pressure of six atmospheres at 32° F. the gas becomes a yellow liquid of sp. gr. 1.33. It may be prepared from any metallic chloride (as common salt), but is directed by the Pharmacopœia to be made from hydrochloric acid by the agency of manganese oxide, the oxygen of which combines with the hydrogen of the acid, and sets free chlorine on the application of heat: $4HCl+MnO_2=MnCl_2+2H_2O+Cl_2$.

LIQUOR CHLORI—SOLUTION OF CHLORINE (CHLORINE GAS DISSOLVED IN WATER).

Preparation.—This, the officinal solution, is formed by passing the gas through a wash-bottle into a receiver containing distilled water, which dissolves it.

Characters and Tests.—The liquor chlori is slightly greenish in color, smelling strongly of the gas, and possessing its bleaching and disinfectant properties—sp. gr. 1.003. On evaporation it should leave no residue.

Under the influence of light, chlorine slowly decomposes water with production of hydrochloric acid and oxygen, and the solution then loses its characteristic properties. Hence the advantage of preparing it fresh for use, and the necessity of employing stoppered dark-colored bottles for preserving it. The *hypochlorites of lime, soda, and potash* owe their special properties to the presence of chlorine, and, as commonly met with, are mixtures of hypochlorites and chlorides, and are known by the name of the latter, as "chloride of lime," "chloride of soda," etc. A solution of the soda salt is known as "Eau de Labaraque," from the chemist who popularized it, and a solution of the potash salt is the "Eau de Javel" of Parisian laundries. Under the influence of feeble acids, *e.g.*, the carbonic acid of the atmosphere, these salts evolve free chlorine until wholly decomposed.

The main chemical character of chlorine is its energetic affinity for hydrogen, which gas it will abstract both from its aqueous and gaseous

combinations. In contact with organic substances it is inactive if they are quite dry, but if any moisture be present, nascent oxygen, or ozone, is liberated under the action of chlorine, and destroys or assists the combustion of the organic compound. A concentrated solution destroys the lower forms of organic life, and the gas brought into contact with sulphuretted hydrogen decomposes it, hydrochloric acid being formed, and sulphur precipitated. Hence chlorine is a good disinfectant and deodorant, but limited in its power, for after it has once caused the oxidation of organic matter, or become changed into hydrochloric acid, its disinfectant qualities are almost lost; also its strongly corrosive action limits its use.

Absorption and Elimination.—Chlorine gas may be absorbed through the lungs, as proved by finding its odor in the brain after death from its inhalation (Cameron). A dilute solution when swallowed combines with the alkaline salts, either in the stomach or the blood, to form chlorides, and as such passes out, mainly by the kidneys. Husemann suggests that hydrochloric acid rather than chlorides may be formed from small doses.

The hypochlorites, decomposed in part by the gastric acid, give off free chlorine, and then passing into the circulation, are excreted as chlorides of potassium and sodium. Kletzinski ascertained this, and taking himself for a fortnight a daily dose of 60 gr. of "chloride of soda" (hypochlorite), found an increase of 30 to 40 gr. of sodium chloride in the urine (Canstatt: *Jahrbucher*, 1851, Bd. i.). Some amount of free chlorine would also seem to pass in that secretion, for after absorption of the gas (in a chlorine bath) Wallace found the urine to possess bleaching properties, though neutral to litmus paper.

Physiological Action (External).—Chlorine acts as an irritant, causing, when applied in vapor or strong solution to the skin, a sense of prickling, with perspiration, congestion, and sometimes erysipelatous, papular, or vesicular eruptions. Chlorine water long applied causes a fatty degeneration and peeling off of the upper layers of the cuticle (Bryk).

On denuded surfaces or mucous membranes the irritant effect is still more marked—the liquor sodæ chloratæ, for instance, if applied too strong to the throat or vagina, causes much discomfort. The vapor, if much diluted with air, may be breathed without other symptoms than a sense of heat and subsequent increase of expectoration; but, if breathed in full strength, it acts as a violent irritant to the respiratory tract, causing spasms of the glottis, convulsive cough, and a sense of severe constriction and suffocation. Death may follow from inhaling an atmosphere of only 1 per cent. chlorine, not from convulsive closure of the glottis, as formerly thought, but from the intense irritation excited, as shown during life by the pain, cough, bloody sputa, etc., and after death by the secretion in the finer bronchi, hepatization of lungs, and (seldom) tracheal croup (v. Hassell and Mulder, Eulenberg).

Some degree of *toleration* of chlorine may be established, for in bleach-

ing works the men can remain many hours where a stranger is at once attacked with coughing and irritation.

Physiological Action (Internal).—The general systemic action of chlorine is that of a *stimulant*, more or less in degree, according to the quantity absorbed; and there is no sufficient evidence of the calmative properties described by Albers.

Circulatory System.—Brought into contact with blood-serum, it coagulates the albumen, loses its characteristic odor, and forms, after a time, hydrochloric acid. In animals dying under chlorine-inhalation, the blood becomes dark red, thick, and finely granular, from similar coagulation of albumen (Eulenberg). A solution injected into the jugular vein destroys life with symptoms of asphyxia, and the blood then also is found dark red, but fluid (Nysten).

In man, normal circulation and respiration are quickened under the moderate influence of chlorine. Husemann, however, states that in typhus fever the pulse and temperature become lower under it, and he connects such effect with conversion of the remedy into hydrochloric acid.

Digestive System.—The same observer traces to this acid change also an increase of appetite and digestive power, but an excessive dose deranges the stomach. Workmen exposed to the fumes of the gas suffer from acid dyspepsia and various symptoms traceable to gastric irritation; it is not likely that any *blood-change* should occur from continuous exposure to the dilute gas, but it is possible that some local solution of gastric epithelium may follow the constant contact of hydrochloric acid formed and swallowed in the buccal secretions.

Glandular System—Nutrition.—Chlorine has been credited with a stimulant action upon the liver and kidney. Kletzinsky asserts that the excretion of urea is increased under its use, and Gubler has observed emaciation, implying increased tissue change. Husemann only remarks that its power of stimulating the hepatic and renal functions "requires confirmation." The fæces are said by some observers to become light-colored under its use, suggesting an alteration in, or lessened secretion of the bile.

Synergists.—Antiseptics and deodorants.

Antidotes and Incompatibles.—In *gaseous* poisoning by chlorine chemical antidotes are—Sulphuretted hydrogen, which forms hydrochloric acid (itself, however, corrosive to the bronchi); ammonia, which forms a chloride of ammonium; and solutions of anilin (Husemann), which also coagulate albumen and are caustic. Probably the best remedy is steam inhalation.

Poisoning by the *solution* is best treated by albumen or milk with magnesia. Kastner says alcohol and sugar are useful. For medicinal purposes, prussic acid and vegetable-colored infusion should not be prescribed with it.

THERAPEUTICAL ACTION (EXTERNAL).—*Aphthæ—Angina.*—As a local detergent and disinfectant, chlorine solution is very serviceable. In cases of aphthous stomatitis I have known it quickly relieve when borax has failed.

In ulceration of the fauces, whether scarlatinal, septic, or syphilitic, a gargle containing about ½ dr. of liquor chlori in 6 oz. of water, is one of the best for removing unhealthy discharge and slough; in salivation also it is useful.

Wounds—Chancre.—A lotion containing chlorinated soda or liquor chlori, about 1 part in 12 of water, is a good dressing for unhealthy suppurating wounds, and for chancres.

Purulent and Fetid Discharges.—An injection prepared with the chlorine solutions (1 part in 12) is effective in cases of offensive lochia after delivery, during puerperal peritonitis, etc. I have found it act better than Condy's fluid, but it produces some dryness, smarting, and irritation, if used too strong.

If an injection be required in *Chronic Empyema*, one with chlorine is very suitable, and freer from risk than some other remedies. In *Gonorrhœa* injections of chloride of lime have proved curative.

As a *disinfectant* for the hands after dissections or post-mortem examinations, liquor chlori is efficient. This was proved on a large scale some years ago at the Vienna Maternity Hospital, when the students were accustomed to pass from the necropsies to the bedside. At one time the mortality amounted to 30 per month, but after the introduction of a chlorine wash for the hands, to be used before and after every post-mortem examination, the mortality fell to about 7 per month, the ordinary average (*Medico-Chirurgical Transactions*, vol. xxxii.).

As an aërial disinfectant, the value of chlorine has been variously estimated. When cholera appeared in 1830 and 1831, chlorine-fumigation was officially ordered for clothes, wool, and other imports, but there was no satisfactory proof of its efficacy. The Board of Health reports of that period, with the evidence of Gregory, Tweedie, and others, rather negative its value in limiting the spread of fever; and Bousquet reported that chlorine would not prevent the activity of vaccine virus (*Lancet*, ii., 1831).[1] On the other hand, Schœnlein and Eisenmann report its value in scarlet fever, and more recently, Dr. Peter Hood expresses great confidence in it in this disorder. He uses towels and sheets wrung from a strong solution of chloride of lime, and placed about the room and before the door; he states that he has never known infection spread when this was

[1] Dr. Baxter has shown, however, that chlorine, added in quantity sufficient to render the lymph acid, abolishes its infective power, and in the same series of experiments found that chlorine in the proportion of .078 per cent. or more, is equally antidotal to the virus of infective inflammation (Report of Medical Officer of Privy Council and Local Government Board, new series, No. vi.).

practised. Internally he gives, at first, a purgative or emetic, and afterward quinine, with the best results (*Lancet*, i., 1869). Mr. Stone (Manchester) reported the vapor effective in staying the spread of cattle-plague; he disengaged it by dropping a few grains of chlorate of potash into a wine-glass two-thirds full of muriatic acid, every six or eight hours; and invented an arrangement for the continuous and regulated supply of the gas in hospital wards, etc. (*Lancet*, ii., 1867).

The general opinion of the profession, and the general result of experiment, is rather against the possibility of controlling infection by this means, at least by a chlorinated atmosphere dilute enough to be respirable; it must be considered doubtful whether emanations from vessels containing lime chloride, or from sheets saturated with it, really exert a remedial effect, though as a measure of precaution they may be worth using. In an empty, closed chamber, the gas, no doubt, is effective, and may be used as described under manganese, but for general purposes sulphurous acid is better.

Phthisis.—The literature of forty years ago contains many cases of phthisis treated apparently with benefit, both in France and this country, by inhalation of chlorine.

Elliotson recorded some advantage from it, and I remember Sir James Simpson speaking well of the method, and pointing out that bleachers did not usually get phthisis, and that the air of bleaching works was found to cure cough. Further experience has not corroborated the expectations formed, although in cases of offensive and copious expectoration some benefit may be derived from chlorine-inhalation.

In *Bronchiectasis* and *Gangrene of Lung*, chlorine-inhalations may certainly give much relief by their stimulant and disinfectant power.

Therapeutical Action (Internal).—*Chronic Hepatic Congestion.*—On the hypothesis that chlorine stimulates the biliary flow, liquor chlori has been given internally in hepatic congestion, and Wallace wrote in favor of vapor baths containing chlorine. It is one element, at least, in the benefit often given by nitro-muriatic acid, internally or in bath; but chlorine alone is not depended upon in modern practice.

In *Scarlatina*, the liquor chlori has been recommended, and acid solutions of free chlorine; but I think there are better remedies.

Preparations and Dose.—*Liquor chlori:* dose, 10 to 30 min., freely diluted. *Vapor chlori* (inhalation of chlorine): take of chlorinated lime 2 oz., water (cold), a sufficiency; put the powder into a suitable apparatus, moisten it with water, and let the vapor that arises be inhaled.

[*Liquor chlori*, Br. P.=*Aqua chlorinii*, *U. S. P.*]

AQUA—WATER, H_2O,=18.

Pure natural water is a limpid, colorless fluid, free from taste or odor. When evaporated, it should leave no residue. In the Pharmacopœia it occurs as "aqua destillata—distilled water," but ordinary water is much more extensively used in practice.

Absorption and Elimination.—Water is readily absorbed into the blood, and especially so if the normal systemic amount has been temporarily lessened by excessive excretion of urine, perspiration, hemorrhage, etc. When the system already contains a normal amount, then an extra quantity is less readily taken up. Elimination occurs by the kidneys, the intestines, the skin, and the lungs, and of any given portion it is commonly completed within six hours, though during strong exercise the muscles retain liquid for a longer time. Of that taken, the greater part passes out by the kidneys, augmenting their functional activity and carrying off a proportionately increased amount of urea, phosphoric acid, and sodium chloride. If the extra quantity of water taken be within moderate limits the increased elimination is accompanied or soon followed by increased absorption.

Physiological Action (External).—This varies much according to the form of application, whether in large or small quantity, by douching, immersion, or wet sheets, etc.; and again according to the *temperature*, cold, tepid, or warm, and according to the shorter or longer time during which the patient is exposed to it. It is desirable, therefore, to consider, in some detail, the different modes of its application.

The Cold Bath.—Temperature from 40° to 60° F., according to the season. What is said under "sea-bathing" (*v.* pp. 151, 152) applies almost equally to the ordinary cold bath taken with a plunge. There is a sudden feeling of chilliness with roughening of the skin (goose-flesh), some blueness of lips, catching of breath, and lowering of pulse. But in a few moments, in fairly healthy persons (and only such should take this form of bath), "reaction" sets in, with sense of warmth and exhilaration, quickening of pulse and respiration, and augmented muscular power. The first effect is due in part to altered conditions of circulation (the superficial vessels being for the moment emptied, and the internal vessels congested), and in part to the sudden shock felt by the large peripheral expanse of sensitive nerve-tissue in the skin. That the nerve-centres can transfer and transmute the sensations and effect of *cold*, as well as other sensations, might be taken for granted, but a familiar illustration of the fact is presented when one hand only is immersed in cold water, and the sensation is transmitted to the cord and brain, and thence *reflected* to corresponding nerve-connections on the opposite side, so that the temperature of this opposite limb is also lowered. That the blood-supply of internal

organs may be controlled by external applications is proved, *inter alia*, by the observed contraction of renal arterioles when ice is applied to the lumbar region (Brown-Séquard), and by the immediate diminution of the volume of a congested liver and spleen under the influence of cold douching (Fleury).

The general effect of a short and satisfactory cold bath is "tonic." The blood circulates more freely, and tissue-change is increased; yet, concurrently, appetite and digestive power are so far improved that during a course of such baths weight is commonly gained.

The *too-prolonged* cold bath, used only through imprudence by the healthy, or for definite curative results in the hyperpyrexial patient, has a very different effect. The primary reaction is succeeded by coldness, depression, weakened circulation, and an exhaustion which may progress to collapse. The temperature is steadily lowered, the blood accumulates in the great venous trunks, capillary circulation and tissue-change generally are interfered with, and reflex symptoms, such as nausea, vomiting, and syncope, may follow. Pugibert and Bailey have lately described a scarlatiniform flush, limited or diffused, as occurring from the cold bath. According to two cases reported by them, this rash is the precursor of shivering, lividity, and a syncope which might prove fatal if it occurred in deep water (*Medical Record*, August 15, 1879). In the clinical use of the cold bath such results are avoided by careful watching and thermometric observation.

Intense cold is an *anæsthetic;* a mixture of ice and salt applied to the skin for a few moments causes it to assume a white or leaden hue, and in this state incisions can be made into it quite painlessly; the rapid evaporation of ether thrown on to the part in fine spray is also used to produce the same effect.

Wet Towels—The Wet Sheet.—A milder method of using cold water is in the form of towels, or a sheet, wrung out, and applied with vigorous friction; it is free from the risk of serious shock to delicate subjects, and is commonly and properly applied before commencing with cold immersion.

The *towel friction* is given first to the upper part of the body while the patient sits with the lower limbs still covered; that is to say, the whole surface is not exposed at one time. Where there is a very feeble state of circulation, or when the breathing is much oppressed, the water may at first be at 80° or 90° F., and gradually lowered to cold, and more of it left in the towel as the power of reaction improves. Under this "graduated stimulation," a pale, bloodless, and sensitive skin may be educated to a good power of reaction, with marked relief to chilliness and to the frequent recurrence of catarrh, and there are scarcely any patients—certainly none who retain the power of taking and digesting food—that cannot receive towel-rubbing with advantage. In catarrhal sub-

jects, however, special care should be used in avoiding exposure at first, or harm may result.

The *wet-sheet friction* is somewhat more trying, since it should always be used cold, and the patient stands, quite uncovered, while the sheet is thrown over the shoulders and round the whole body, and friction is applied by making folds in the sheet, not by simply rubbing the smooth surface. This should be continued for two, three, or four minutes. It is suitable for persons not much accustomed to cold water, but with a fair amount of vital power. "It rouses all the activity of the nerves and blood-vessels of the skin, without taking much animal heat from, or calling for much organic exertion of the frame, and while doing this it transmits to the nervous centres the genial stimulation which it impresses on the great nervous outer covering of the body" (Gully). It relieves fatigue, and may be taken when a cold bath would be unsuitable; it relieves, also, nerve-depression and early stages of catarrh and neuralgia. To use a warm sheet, unless followed by a cold one, is not attended with any of the good effects of this kind of bath; by a sheet so wet as to be "dripping" a more powerful effect is exerted, whilst by wringing the sheet very dry from the cold water, quicker reaction will be ensured. The patient should not attempt to rub himself much, or make any violent exertion during this process, otherwise he may be annoyed by giddiness or palpitation.

Shallow Bath.—This is given with about six inches of water in a bath long enough for the patient to sit with the legs in, though he need not lie down. The water should be splashed, and rubbed, and thrown over the body by means of a towel used by an attendant at the back, while the patient splashes his front for from one to five minutes, according to the reactive power. The frequent change of the splashing water against the body lowers temperature for the moment, and rigorous friction is required afterward, or walking exercise. The same bath more or less completely given, is the ordinary morning "tub" of average Englishmen, and exerts an excellent tonic and anticatarrhal effect. During acute febrile disorder the shallow bath may be used at 70° to 80° F., and much exertion is not desirable, nor is friction required; but in the absence of acute disorder it should always be taken cold in summer, or at about 60° F. in winter, and be followed by exercise. Its ultimate effect is to equalize circulation, but it encourages it especially in the lower extremities, and so relieves the head and the viscera.

The Pail Douche is administered by throwing two to four pails of water (six or eight gallons at a time) over the shoulders, against the back, or the front of the chest, as the patient sits in a long bath. A dry towel friction follows. This process adds the shock of dashing water to the splashing of the shallow bath, and imitates, to some extent, the wave-stroke of the open air sea-bath. It needs more power of reaction than

the baths already mentioned, and, if well borne, has much more effect in relieving internal congestion, whether of the liver, the uterus, or the nerve-centres. The amount of force used, and the number of pails, should be varied with the vital conditions of the patient. In chronic hepatic and cerebral congestion, usually much force will be borne.

Spinal Washing.—This is a mild and local form of douching from a jug, or can, or large sponge, emptied along the spine as the patient sits on a board placed across the front of a bath. It may be continued from two to ten minutes, and sometimes should be commenced at 80°, and gradually cooled down, until after a few baths it can be borne wholly cold. If commenced too cold, in sensitive subjects it may give rise to headache or giddiness, and if continued too long may induce a rheumatic condition of the back-muscles, and is not free from risk to the kidneys. It would seem that the spinal cord is directly stimulated by the shock of cold water, and that the stimulus is reflected to peripheral and visceral nerves; hence, according to hydropathic authorities, "a divergent effect on the action of the heart, stomach, kidneys, uterus, etc." It is probable, also, that the sympathetic ganglia are directly stimulated, and this bath is useful in functional torpor, marked by numbness or slight paralysis of limbs, constipation, and phosphaturia, etc. Certainly, a very bracing effect and pleasant glow may be produced by a moderate cold wash to the spine, followed by manual friction, and the effect may be further developed by the use of a "rubbing wet sheet" to the whole surface for a few minutes afterward.

The Douche.—This bath is the most powerful and the most important within the domain of hydro-therapeutics, and has been made the basis of the system practised with much success by Dr. Fleury, at Bellevue (Paris). Its effect varies with its size, force, direction, duration, and temperature. It may be a column of water from one to three inches in diameter, falling twelve to twenty feet, or propelled at right angles to the patient's body. It may be broken up into fine streams by a rose, or into more numerous jets, arranged to play at once on the body from different quarters (*douche du cercle*—needle douche). Again, it may be used tepid, hot, or cold, or all three at one sitting, and its duration may vary from ten to sixty seconds, or in healthy people more.

The cold douche should be commenced cautiously, after due estimation of the patient's reactive power, and if there be much debility, it should be applied at first to the extremities only, and for a very brief period—ten to fifteen seconds; this is a most important point: it should never be applied to the head. In disease, the douche is, as a rule, suitable only for chronic cases, but with careful management may be applied to almost all conditions.

According to Dr. Howard Johnson, the cold douche markedly increases the respiratory acts, and "thereby imparts an enlivening influence to all

the vital phenomena." "It is a diffusible stimulant, and is comparable to ammonia," though it does not always quicken the pulse. According to Fleury, the general douche, in shower, jet, or circle, is powerfully tonic and reconstitutive, by virtue of its action on the circulation. With an increased force of percussion, rapid movement from one part to another, and fine division of the liquid, a more exciting effect is produced. By directing the stream upon various parts in such force as to congest them, a revulsive action is made to relieve the congestion of other parts; thus, metrorrhagia and vomiting, even when dependent upon a uterine polypus, have ceased under a course of cold douching (Fleury, third ed., p. 297), and the volume of the liver and spleen has markedly diminished. Andral and Piorry verified the extent of hepatic dulness in a certain patient as 18 centimetres (vertical) and 11 centimetres to the left of the median line (horizontal), and agreed that immediately after an energetic douche, the former measurement was reduced by ½ centimetre, the latter by 5 centimetres; and in another case, the spleen, which measured at the commencement of treatment 23 centimetres vertically and 15 transversely, measured only 9 and 7 centimetres respectively after six days of repeated local douching. The effect on other organs is similar, though less rapid. But in chronic cases, it is important not to induce such results too quickly, since fresh and more serious congestion may be produced elsewhere.

In certain disorders, such as dropsy or effusion into joints, *absorption* has been markedly stimulated by the douche (Fleury).

The Sitz Bath.—A valuable influence may be exerted not only on the pelvic organs, but indirectly on the whole system, by sitting in water of varying depth and temperature (60° to 80° F.) and for a time varying from 5 to 30 minutes. "The immense network of nerves which supplies the whole of the organs contained within the hips and the lower belly, and the lower third of the spinal cord, terminating in great leashes of nerves, are the sensitive points upon which the sitz bath operates" (Gully). It certainly "draws blood from the brain," and is one of the best means of insuring sleep. It relieves fatigue, improves appetite and digestion, lessens headache and giddiness, regulates the bowels, and the uterine flow, and the action of the kidneys, often augmenting them when deficient, or lessening if excessive.

To obtain these good effects it is most important that thorough reaction be secured by friction or exercise, or warm clothing, otherwise shivering and depression come on. It may be advisable to commence with *tepid* water, or a more powerful stimulus may be given by a "running sitz," fresh cold water constantly entering the bath and circulating round the body. Or again, a local douche may be made to act upon the lumbar region, the perineum, the uterus, etc., whilst the ordinary sitz bath is in progress. The *general* effect of the cold sitz bath is *sedative*. It slows the pulse to the extent of 10 or 15 beats during the first five minutes—of 20

beats in the course of half an hour (H. Johnson). It also lowers the respiration, though very slightly, and it lessens the body temperature. By its rubefacient effect, the sitz bath acts also as a derivative or counter-irritant.

Foot-Baths.—The immersion of the feet produces some of the effects of the sitz bath, but in a minor degree. It lessens the amount of blood in the cranial circulation and relieves flatulence and slight visceral congestions. For all purposes, the thorough-going hydropathists use foot-baths *cold*, or at least cool, with considerable friction, but there are some subjects in whom the *cold* to the feet produces serious symptoms, and others—such as the gouty and catarrhal patients—in whom a *hot* foot-bath, to which mustard or pepper may be added, relieves, and under due precaution as to exposure, does so more pleasantly and effectually than the cold. Friction of the feet with a "damp or dripping towel" is, however, an intermediate method often available.

Wet-Packing.—This is a still more sedative process than the sitz bath, since it is applied over a larger surface, and involves complete rest. To avoid unduly rapid depression of circulation and general activity, it is often advisable to commence with a *partial* packing, *i.e.*, closely applying to various parts folded towels wrung from cold water, and covered with flannels and waterproof sheeting. Thus the hips and loins may be "packed" from the level of the navel to half-way down the thigh; the abdomen, from the lower edge of the ribs to the hips; the chest proper, over the ribs, or the whole front and back of the body; it is said that packing applied to the chest exhausts more than packing of other parts of the body (Gully). Again, packing of the lowest part of the belly and back, of the whole spine, or of the sides, are other varieties; the wet towels may be changed every fifteen to twenty minutes for an hour or two.

The complete general pack is applied by covering the whole body with a wet sheet, and this with several blankets, the patient lying thus covered for about one hour. This process lowers the pulse and temperature and weight, and is compared by Johnson to antiphlogistics, leeches, calomel, and antimony. It may be used at once in chronic cases in sanguineous irritable subjects, but should be practised with caution in anæmic weakly persons. It usually, though not always, induces moderate diaphoresis, and it should be followed by a shallow bath of two to four minutes' duration, and then friction. The water, urea, and chloride of sodium in the urine, are increased under the use of the wet-pack—slightly so from a moderate use of it, considerably if it be continued from three to four hours.

There is more discomfort, with chilliness and depression, produced by the routine use of this agent in hydropathic establishments, than by any other measure. In febrile conditions it may be of the utmost value, but

even in such cases I have seen serious results from the exhaustion induced.

Compresses are partial packings, and exert a marked local soothing effect. "They serve both to prevent and to relieve irritation," and much misery of indigestion and of torpid bowels is avoided by the almost daily use of a compress over the stomach. Various forms of joint-pain may be relieved by the cold compress, and a similar application to the epigastrium will often induce sleep in cases of insomnia from excessive brain-work or anxiety.

The frequency of changing the cold wet cloth must vary with the effect desired. *Soothing* is not induced till a certain amount of heat is withdrawn from the part, and if the compress is allowed to get too warm it is apt to *stimulate* and irritate. In acute bilious attacks, the stomach-compress should be changed about every two hours (Gully); in chronic gastric irritation, five or six hours will be a suitable time, and in chronic pulmonary disorder, eight or ten hours; in inflamed throat, every six or twelve hours; in contusions, every half-hour, while in congestions, such as of the testicle from sexual irritation, or of the uterus, every five minutes change for one to three hours gives most relief.

Preissnitz, Fleury, Gully, and others strongly object to compresses being applied warm, but I have often found them useful.

Warm Baths.—By an action contrary to that of cold baths, these *attract* the blood *primarily* and directly to the part exposed to their influence, relaxing the vessels and tissues, and leaving them afterward in a condition of lessened tonicity. A similar effect is exerted by all kinds of warm baths, but it differs in *degree* according to the temperature and duration. By a *tepid* bath is meant one at from 70° to 80° F., and this is chiefly used for cleansing and moistening the skin—a temperature of 92° to 98° F. gives a *warm*, and upwards to 112°, a *hot* bath. With the former there is at first a pleasant sense of soothing and refreshing warmth, the skin reddens, and the pulse quickens in frequency, while it lessens in tension; the respiration is also quickened, and the temperature rises. If the bath be too prolonged, a sense of languor comes on, and after it there is less aptitude for exertion than before. Under favorable conditions, excretion is increased from the skin, the kidneys, and the lungs, at the time of the bath, and oxidation is lessened subsequently.

In a *hot bath*, 98° to 112° F., the first sense of heat may be painful rather than pleasant, then a general stimulating effect is perceived, the whole surface becomes deep red, and the cutaneous veins distended; relief is thus given to internal congestion, to pain, and muscular spasm and convulsion. Complete muscular relaxation follows, with greatly diminished tension of the pulse, and increased frequency of heart-action; before very long, a sense of oppression and distention may be felt in the chest and head with general languor, giddiness, or faintness from paralysis of vaso-

motor and cardiac inhibitory nerves. These unpleasant effects occur much sooner in some persons than others.

By a hot bath perspiration is usually, but not always, increased; and sometimes from the high temperature of internal organs a restless, heated condition, similar to that of true pyrexia, may be induced for a time. This may be noticed, especially after a too-prolonged use of the hot strong saline baths (Droitwich, etc.).

The length of stay in a hot bath should depend on the purpose to be accomplished, whether (1) mere excitation of circulation in the skin (which is effected by a short bath with or without the extra stimulus of salt or mustard), or (2) perspiration and relief of pain (which require, perhaps, half an hour), or (3) complete muscular relaxation (which needs a prolonged immersion). In contradistinction to the ultimate tonic effect of the cold bath, decided loss of weight results from a course of warm bathing (A. Steffen).

Contra-indications.—Since the thoracic organs and the brain become more or less congested during a hot bath, its prescription needs as much caution as that of cold bathing, though for a different reason: pulmonary or cerebral vessels may even give way, especially if the latter be atheromatous. According to Dr. Steffen, hot-water baths are pre-eminently contra-indicated by congestion or œdema of the lung, and Dr. H. Wood has seen under such conditions, "the most frightful dyspnœa result." In such an accident, cold effusion should be freely used.

Hot Fomentations.—As cold water may be usefully applied in local compresses, hot water is often of the greatest service applied in fomentation, *i.e.*, when a thickly-folded flannel, or any thick absorbent substance, such as spongio-piline, is completely wrung out of hot water, and placed on the affected part, covered with dry flannels, oil-silk, or mackintosh outside, to prevent evaporation and retain heat, and changed again frequently, the process being continued for half an hour, or even for several hours if necessary. This stimulates the external skin much more strongly and suddenly than any cold compress, for every degree *above* the normal skin-temperature is felt much more acutely than every degree *below* it (Gully), and it acts much better than the more equable heat given by hot salt, hot bran, or tins, or caoutchouc bags of hot water, because the high temperature is more constantly renewed.

If there be congestion, or even inflammation of an internal organ, it may be relieved by such external application which is especially indicated when the patient is too feeble to react to cold, or when the pain and irritation are very severe, and "of the mingled nervous and inflammatory kind, with, if anything, an excess of the former." The direct application of quite hot water causes contraction of small vessels and also of the uterus.

Steam-Baths.—The vapor of water, in the form of the steam-bath,

lamp-bath, hot wet-packing, or Russian bath may be used to accomplish still more thoroughly the same objects as those to be expected from the warm or hot bath. In one good form of vapor-bath, the patient sits unclothed in a chamber to which steam is admitted, but the head is outside, covered with a cold cloth. In a less complete, but more portable form, the patient sits on a chair covered with blankets, while steam is generated by a spirit-lamp placed under a pan of water: or a somewhat similar result may be obtained by dropping freshly burned lime into a bucket of water under the chair, or a heated brick into hot water; or if the patient be too weak to rise, steam may be conducted under the bed-clothes raised by hoops; or a heated brick, wrapped in moistened cloths and flannels, laid near each limb. The most complete form of such bath is, however, the Russian bath, which is given in a closed chamber filled with steam. On first entering the bath there is often a disagreeable sensation of heat and burning in the skin, the pulse becomes quick, and respiration uneasy; sometimes there is a feeling of pressure on the eyes, heaviness in the head, and dizziness; but these symptoms soon pass away, and the respiration becomes more natural and deeper, the blood finds easier access throughout the body, the skin soon gets red and moist, and the patient comfortable.

Eulenburg states that the steam-bath raises the body temperature to a very appreciable degree; on an average a steam-bath of 41° to 42° C., by 1¼ to 1½ degree C. ("Real-Encyclopædia," 1880, i., p. 708).

Turkish Bath.—In conjunction with other baths should be considered the Turkish, or Anglo-Turkish bath, in which dry *air* at a temperature of from 100° to 160° F., or more, is employed, the patient passing through graduated chambers during 20 to 40 minutes; when free perspiration has occurred, and lasted for some time, shampooing is commenced, and afterward the body is washed with copious lathers of soap and streams of water, warm, tepid, and finally cold. The effect of the warm applications and frictions is to stimulate both the general and cutaneous circulation, to relax the muscular tissue, relieve pain and congestion, to cleanse the openings of the skin-glands, and to eliminate through them morbid material and retained excretion. That the skin excretes urea has been proved by finding it in the perspiration of healthy persons (Landerer, Funke, Leube, etc.); but still more constantly in cases of scarlatina, nephritis, cholera, collapse, and chronic Bright's disease (Scottin, G. O. Rees, Fiedler, etc.). In such cases the urea may even form a crystalline powder on the skin, especially near the sweat-glands (H. Wood). Moreover, in diabetes the perspiration contains sugar; in rheumatism, lactic acid; in gout, uric acid; and in jaundice, biliary products. This being so, it is evident that the promotion of very free secretion from the skin-glands by the varied processes of the Turkish bath is a most efficient means of depurating the blood. The effect of the final cold douche or

plunge is to contract muscular tissue both in the skin and deeper parts, and to stimulate and brace up the nervous system; hence this form of bath combines the good effects of both hot and cold applications. It should induce an agreeable sense of vigor and elasticity, and render the skin less sensitive to changes of temperature.

It does not, however, always succeed well; in some subjects, especially at first, sweating is not favorably induced, and they suffer from heat, malaise, and headache; the use of a wet towel with friction should then be tried, or gentle douching with warm water on first entering the bath; drinking cold water is also recommended for increasing the skin secretion, and often succeeds, but in my experience it has sometimes caused nausea and gastric pain.

Persons vary in their power of resisting heat, and although there are really few who cannot go through a Turkish bath with safety, there are many who suffer at first with some degree of oppression, faintness, and exhaustion. Hence, the first bath should be taken cautiously, not prolonging unduly the time in the hot chamber—say not beyond 20 to 30 minutes (the sensations will practically guide as to time), and finishing with the cold or nearly cold douche for a few seconds only, not with the plunge bath. It is a mistake to go over-fatigued into the Turkish bath, or within three or four hours after a good meal; or to dress too hurriedly, and go with still-perspiring skin into the open air.

Contra-indications to this form of bath are to be found in extreme debility from any cause, and in some conditions of pulmonary congestion or tendency thereto: chronic heart disease *per se* does not necessarily negative the bath, but requires extra precaution.

Dry or Blanket-Packing.—In this process the patient is enveloped in six blankets, one at a time, each accurately adjusted about the throat and feet, so as to be air-tight; a feather bed is thrown over all. Dr. Howard Johnson speaks highly of this treatment, which he credits with producing the same results as vapor or Turkish baths, without so much general perturbation. After a time, the air next the skin is so far heated as to excite the circulation, and stimulate a flow of perspiration, and after this has lasted for half an hour or an hour, a shallow bath at 70° or 60° F. and a dry friction complete the process.

Though weight is temporarily reduced and excretion increased by this, as by other warm baths, it does not necessarily follow that the general condition is impaired; on the contrary, in satisfactory cases, even after profuse sweatings, weight is ultimately gained owing to increased appetite and assimilation.

Mustard-Bathing or Packing.—Mr. S. Newington has drawn attention to the powerful derivative effects of the hot mustard-bath. Two handfuls of mustard powder are tied in a cloth, and pressed in hot water till a very strong extract is obtained, which is mixed with the water of a

full hot bath, and after the patient has entered this (the genitals being protected by a folded towel), a blanket is laid over the bath to prevent irritation of the eyes. After five to ten minutes' stay the patient is dried and goes to bed. A similar, but milder, application is that of a sheet wrung out of mustard infusion and covered with waterproof. The effect is to strongly excite the capillary circulation in the skin, and so to relieve internal congestion, especially of the nerve-centres, and hence it greatly disposes to sleep and quiet in conditions of mental excitement. Under packing of the trunk in towels wrung out of the hot infusion the pulse came down from 108 to 60 per minute in the course of two hours (*Lancet*, i., 1865).[1]

Physiological Action (Internal).—Water is an essential constituent of the animal tissues, and their healthy growth is dependent on its sufficient supply. In passing through the system, water (1) assists the circulation of the nutrient fluids; (2) renders oxidation and other chemical changes more active; (3) by its solvent action promotes absorption, secretion, and excretion; and (4) by its evaporation from the surface gets rid of superfluous heat. The tissue-change produced by medicinal water drinking is greater in the young and delicate than in robust adults; it is promoted by increase of temperature whether of the water itself or of the atmosphere; also by bodily exercise (Parkes). The ultimate result of a judicious course of water drinking is increase of weight, and (it is said) of fat (Bartholow), but if an *excessive* amount be taken, the blood is rendered unduly fluid, the corpuscles become paler and less healthy, and general nutrition is impaired.

Large draughts of *cold* water, especially if taken on an empty stomach or when the body is heated, act injuriously, by giving a shock through peri-

[1] Schüller (of Laubbach) has studied the effect of various applications of water on the cerebral circulation of rabbits after trephining and removing the cervical sympathetic on one side. Compresses over the abdomen at 50° F. caused dilatation of vessels of the pia mater; a general bath at 50° induced the same effect in greater degree. After similar applications, but quite cold, a gradual contraction of cerebral vessels occurred in five to ten minutes, and lasted for about half an hour. Warm water, 95° to 99°, applied in the same manner caused marked contraction of the same vessels. A douche over the belly and back caused alternating changes. Injections into the rectum induced moderate dilatation. Under a cold pack, gradual and strong contraction occurred, lasting often for two hours, pulse and respiration were slowed, and reflex irritability was reduced. Ice on the head caused, after a time, moderate contraction; friction over abdomen had the same effect. We can scarcely draw definite practical conclusions from these observations, but it would seem that tepid applications over the body lead to *dilatation*, and quite cold or hot applications equally cause *contraction* of cerebral vessels. Schüller considers that extreme degrees of temperature are contra-indicated in cases of hyperæmia, congestion, and anæmia of brain, and that the main good effect of baths is exerted in depleting cerebral vessels, in giving tone to the muscular coat of arteries, and indirectly the cardiac muscle, and thus improving nutrition of nerve-centres (British Medical Journal, i., 1876).

pheral nerves to the abdominal sympathetic, and may cause nausea, faintness, actual syncope, and in some cases even death. Draughts of *warm* water, if not rejected by the stomach, act more quickly than cold upon the skin and the kidneys; they usually *cause* or assist vomiting, but if a pint or more be taken it will often *stop* vomiting by distending and paralyzing the stomach. I have also known even a *moderate* quantity of hot water stay vomiting when ice had failed to do so; and again, a small quantity —two or three teaspoonfuls—of quite hot water, taken at short intervals, has arrested reflex vomiting, *e.g.*, after ovariotomy.

A certain amount of fluid taken with meals assists digestion, but too much impairs it by over-diluting the gastric juice, and hurrying on the passage of the food. Its *temperature* is of importance, for if taken hot, especially with a substantial meal, it is liable to distend and enfeeble the stomach, while if iced, it does harm by contracting capillaries and diminishing normal blood-supply, although, indeed, a healthy stomach will tolerate, for a time at least, these and many other injurious things. Warm liquid, such as tea, taken *shortly before* a substantial dinner, will commonly disorder the digestive functions sooner or later, but this is not wholly due to the fluid, but to its astringency, etc., for a warm nutritious soup at the commencement of a meal suits many persons. If they are fatigued, it supplies nourishment in a form which is readily taken up, and enables solid food to be better digested.

Taken later on in the meal, at the end, or an hour or so afterwards, fluids, cold or warm, materially assist completion of the digestive process, and the onward passage of peptones and the other contents of the stomach.

It is well known that water exerts a marked influence on the fermentative process: thus sugar, anhydrous or mixed with but little water, does not ferment at all; with moderate amounts of water the vinous, and with an excess of water the acetous fermentation takes place, and it is very probable that water exerts analogous influences on the food. Bacteria will not develop in a *concentrated* solution of albumen.

Therapeutical Action (External).—*Hemorrhage.*—The application of iced or cold water is an old, and commonly an efficient method of restraining hemorrhage from small vessels. The jet of water, or the soaked cloth or sponge should be applied suddenly for a few moments at a time. Mr. C. B. Keetley has lately drawn attention to the value of hot water as a hæmostatic, and quotes a case of thigh-amputation, where a sudden drenching with water at 120° F. stopped the bleeding after cold water had failed to do so. He suggests that in such cases it acts as an excitant to the nerves of the small vessels, and perhaps directly irritates the muscles themselves (*Practitioner*, February, 1879). Dr. Paul Brown found water at 150° F. succeed well in staying hemorrhage after an amputation when Esmarch's bandage was removed (*Medical Record*, 1879).

Mr. Keetley has also found hot water efficacious in epistaxis, though he acknowledges that "it is powerless against it if of a certain grade of severity," and I have myself seen its use in a very severe case followed by serious results. During one attack the attendant had applied it for some time, though the bleeding continued, and the patient became alarmingly prostrate. I stayed the flow quickly with cold water, but in a second attack, some weeks afterward, I heard the hot water treatment was again employed, and the patient died of syncope.

In Uterine Hemorrhage the results of hot water injections have been more satisfactory. Windelband used it at 117°, 120°, 124° F. (*Medical Times*, 1876). Emmet (New York) and Whitwell found it very safe, efficient, and disinfectant in post-partum hemorrhage (*Lancet*, i., 1878, p. 920). Lombe Atthill uses it constantly (at 110° F.) in his practice at the Rotunda, not only in hemorrhage, but also in chronic uterine congestions. Ricord finds a hot uterine douche, 122° F., "almost infallible" in menorrhagia. C. Richter uses hot douches for hemorrhage in childbed, and reports 105 cases occurring in the Charité (Berlin) where they had been employed with excellent results; he recommends injections of three to five pints at 122° F. into the uterine cavity through a catheter, and for the sake of disinfection adds a proportion of 1 per cent. of carbolic acid; he says that the hot water coming in continued contact with the inner surface of the uterus causes a soaking and swelling of the tissues, particularly of the peri-vascular connective tissue, and thus checks the hemorrhage (*Zeitschrift für Geburtshülfe und Gynœcologie*).

Peter recommends it for cases of non-puerperal hemorrhage; his theory is that through the irritation of the lumbar ganglia the vaso-motor nerves get into a state of "over-activity," and that the vessels contract accordingly (*Centralblatt für Gynœcologie*). I have myself ordered hot water injections in several cases of uterine hemorrhage, directing a stream at 122° F. into the uterine cavity, and the effects have been various. When hemorrhage arose from cancer, sometimes there was immediate relief, which lasted for some days, but in others the bleeding was increased; when the bleeding arose from a retained portion of the placenta a larger flow occurred; when caused by an atonic state of the uterus the hot water injection alone did little good, but when alternated with cold injections, 60° to 70° F., the result was excellent. In all other cases of hemorrhage the effect was beneficial. I am satisfied that the water should be as hot as possible, otherwise success cannot be secured; and I agree with Runge in calling it "a non-infallible but an important remedy." It is already largely used in London practice, with very general satisfaction. Hot water bags applied to the lower part of the spine also prove useful in uterine hemorrhage.

Ulcers, Wounds, Contusions, etc.—The "cold water dressing," with wet lint cut accurately to an ulcerated surface, or amply covering an in-

flamed part and overlapped by oiled silk or gutta-percha is one of the best, as it is the simplest, application for ordinary cases. In abscess, warm fomentations expedite the pointing and relieve tension, pain, and other symptoms. They are useful in encouraging bleeding from leech-bites, etc., and in assisting the separation of sloughs. In more severe wounds, if there be much heat and irritation, it is well to keep the dressing constantly moist, uncovered by waterproof, and the most complete method of doing this is by *irrigation* from a can of water over the bed—a small stream percolating the dressings, and draining into a basin on the floor. On the other hand, sometimes, the cold water treatment of wounds is too depressing, and leads to slowness of repair, or sloughing, and the hot water dressing or immersion has been recommended in such cases, especially by Professor Hamilton (New York) and some other American surgeons. If recent lacerated or incised wounds of unhealthy character are kept constantly under hot water (95° to 100° F.), there is a sense of comfort induced, not absolute relief from pain. On the second or third day, the parts adjacent are swollen, but not much reddened; the integument is sodden and white. On the fifth day, or later, the swelling is sometimes great, and the granulations covered with a white exudation, but the area of acute inflammation is much limited; erysipelas and gangrene are arrested or restrained; traumatic fever has seldom, and septicæmia has never occurred in any case in which submersion has been practised from the first day (New York *Medical Record*, May, 1874). Of course, simple incised wounds and healthy amputations do not need such an elaborate method of treatment.

Hot water is very useful in the treatment of recent sprains, the affected limb being immersed in it at the highest endurable temperature for about fifteen minutes (*Medical Record*, 1879).

For Burns, Cellulitis, Sloughing, Phagedæna, Sloughing and Phagedænic Chancres, immersion in the hot bath is extremely efficacious, relieving pain, limiting the disease, hastening separation of the sloughs, cleansing the wound, etc.

Hernia.—A bag of pounded ice placed over a hernial protrusion has caused its reduction; the cold lessens the volume of the contents of the gut, especially of the gases; it also stimulates peristalsis, and causes contraction of vessels.

Heat also is used for hernia by fomentation, or better, by the hot bath. It relieves pain, allays spasm of muscles, and so favors reduction: the taxis should be employed while the patient is in the hot bath, which should be continued until muscular relaxation is complete.

Stricture—Retention of Urine.—A lump of ice introduced into the rectum is a favorite remedy for retention of urine. Immersion in a hot bath, by relieving deep congestion and allaying muscular spasm, is very useful in similar retention, especially when due to congestive or spas-

modic stricture, or to either of these conditions, added to organic stricture. The application of a hot sponge or fomentation to the genitals and hypogastrium is the simplest way of relieving "nervous" retention.

In *Orchitis*, iced water made to circulate through a tube coiled round the affected testis will often relieve pain instantly, and entirely cut short the attack. It should be applied early. A similar coil applied to the penis has been introduced by Dr. Otis for the treatment of hemorrhage from the urethra after internal urethrotomy.

Bubo—Hæmorrhoids.—In these maladies also the application of ice or cold water is often serviceable. At other times hot fomentation gives more relief, as it may do in orchitis.

Varicocele.—Suspending the scrotum in cold water night and morning, braces up the dartos and the muscular tissue in the veins, and relieves this malady.

Vesical Catarrh.—Warm hip-baths are of much value in this condition, and may be employed two or three times daily, for half an hour or an hour at a time. In gonorrhœal inflammations and discharges they are also good.

Catarrh.—In frequently recurrent attacks of this affection—"always catching cold"—a condition generally dependent on impaired nerve-power and over-sensitive skin, the Turkish bath proves very useful; but when inadmissible for any reason, simple cold wet-towel friction in the morning should be substituted.

Tonsillitis—Diphtheria.—Thick compresses wrung out of cold water, applied to the throat and covered with flannel, usually give much relief, but sometimes answer better when soaked in very hot water (112° F.) and applied over the front part of the neck and chest, covered with flannel and oiled silk, and renewed every four to six hours.

Croup.—In true inflammatory croup, a very hot compress or sponge and steam-inhalation are especially to be recommended, and having been satisfied with these I have not often used the cold applications recommended by some authors.

In *Spasmodic Croup*, however, a cold wet cloth to the back of the neck and the larynx during the attack, and douching the spine or the whole body once or twice daily, is an effective treatment.

Thoracic Inflammations.—Niemeyer and other high authorities, chiefly German, have strongly advised continuous cold applications in the early stages of thoracic inflammation, both pleuritic and pneumonic, placing compresses over the affected side, and changing them frequently: they now even prefer the ice-bag in such cases. In English practice, however, this method is still regarded as involving unnecessary risk, and it has not been generally adopted.

Phthisis Pulmonalis.—The cold douche is used externally in phthisis, chiefly in Görbersdorf and Davos. It is only suitable for cases where

the temperature of the body is normal, and the disease not actively progressing, and should be employed with the greatest care and under medical supervision. The patient at first is rubbed with dry towels, and then, on being made to take a deep inspiration, is exposed to the cold douche for five seconds—by degrees the duration of the douche may be prolonged, if desirable, to forty-five or sixty seconds—immediately after, the body is dry-rubbed until the skin gets red and warm; the patient is then dressed, and active exercise, such as walking uphill, completes the process. Anæmic patients cannot bear the douche for more than five or ten seconds. When this treatment *can* be borne, it promotes appetite and digestion, and renders the patient less susceptible to the injurious influences of a changeable climate.

Fevers.—The application of water to the treatment of these disorders is one of the most important results of modern therapeutics—or rather of a revival of, and improvement upon, older ideas, for it is not wholly modern. Wright and Currie adopted it in 1786–1796, using cold effusion, *i.e.*, dashing several buckets of water over the patient when stripped. The latter physician records an epidemic of typhus fever affecting 58 soldiers, most of them severely: 56 were treated by cold salt-water effusion, and all recovered; the other 2, considered too weak for this treatment, were the only fatal cases. He traced an evening exacerbation, and insisted on the importance of using the remedy during this access: or at least during a period of great heat, and not during a rigor, nor during a profuse perspiration ("Medical Reports on the Effects of Water," London, 1798). His method of treatment, although valuable and successful, was too harsh for ordinary use; but soon after his observations, Giannini, of Milan, advocated immersion in cold water for two to fifteen minutes in all forms of fever (especially intermittent, petechial, rheumatic, and scarlet fevers); he drew up very judicious rules for practice, and he had very good success, but he objected to the use of ice ("Della natura delle febbri," Milano, 1805). Fröhlich (1822) was one of the first to regulate his practice of cold or tepid bathing by the thermometer. An account of his and many other earlier observations has been given by Fleury ("Traité d'Hydrothérapie," Paris, 1866). In our own time, Ziemssen has improved upon the older methods, by his process of gently lowering the patient (with a sheet) into a bath at a temperature of about 98° F., and then gradually cooling it by addition of cold water or ice to 80° or 72° F., or even lower, according to the effect produced; this should be noted by a thermometer (placed in the rectum if possible). When a distinct reduction of the fever heat is evident (it may be in five minutes or in thirty), the patient is dried, and laid again in bed, and the process may be repeated two to six times daily. A less complete mode of attaining a similar result is by cold compresses to the trunk, ice-bags to the spine and other parts, injections of iced water into the rectum, or the wet-sheet

pack. All such applications, valuable as they are, must be carefully watched: they depress the circulation, sometimes extremely, and may need, after their use, stimulants internally, and hot cloths and bottles externally, in order to relieve too-cold extremities, blue lips, and tendency to collapse. The bath generally used in Germany has a temperature of about 70° F., or somewhat lower, and the patient is kept in it for about ten minutes, but very weak subjects only from five to seven minutes. Ziemssen now uses this bath, I believe, more frequently than the *gradually* cooled one, mostly mentioned with his name.

Hyper-pyrexia.—According to general, though not universal experience, a rise of temperature above 108° F. is quickly fatal, and a range between 105° and 112°, which may occur in acute rheumatism, etc., has been specially termed "hyper-pyrexia." Under the systematic use of cold applications, some remarkable recoveries from this critical condition have taken place, and two cases fully reported by Dr. Wilson Fox attracted much professional attention to the subject. They were both cases of rheumatic fever with cardiac complications: one, a woman of forty-nine, was lowered at 9.50 P.M. into a bath at 96°, when her temperature was 109.1° F. She was unconscious, the pulse imperceptible, the face cyanotic, the respiration irregular and gasping. At 9.55 P.M., the rectal temperature was 110°. "Ice was fetched, a large lump was placed on her chest, another on her abdomen, a bag filled with ice was tied down the length of the spine, and while two assistants bailed the warmer water out of the bath, two others poured ice-water, as rapidly as the pails could be filled, over the patient." At 10.10 P.M., temperature was 109.1°; at 10.25 P.M. it was 106°; the pulse now became perceptible (140), and the patient showed signs of consciousness. Brandy was freely given. At 10.35 P.M. the temperature was 103.6° F., and the patient was taken out of the bath. At 10.55 the temperature was 100.6° F., lividity had disappeared, the patient could speak, and had a certain imperfect consciousness; the temperature continued to fall, till at 11.25 P.M. it was at 97.4° (vagina), and hot applications and an enema of brandy were required to prevent collapse. Another bath was given next day, when the body temperature had risen to 104.5° F., the bath was at 64° F., and was continued for twenty minutes; on removal, the patient's temperature was 103.9°, and it continued to fall for forty minutes longer till it reached 99.4°. Rigors occurred, and hot applications were again required. From this time, the cold treatment was continued by ice-bags to the spine, which sometimes were effective in reducing the body heat, and sometimes not, but within a week from the baths, the patient was sitting up convalescent, and within a month was able to travel.

The second case presented more difficulties, and required a longer treatment: it occurred in a man aged thirty-six, suffering from double pneumonia, double pleuritis, and pericardial effusion. On the seven-

teenth day of his disease, the temperature rising rapidly to 107° F., and delirium setting in, he was placed in a bath at 89° F., which was cooled to 86°. The after-effect of this was a fall of body temperature to 98°, and return of consciousness. For eight days cold applications were kept up almost continuously; eight baths were given, of duration varying from twenty-five minutes to seventy minutes, and in the intervals, the ice-bag or wet-pack was used, the object being to keep the temperature under 103° F. at least. This patient also made a good recovery, but the temperature did not remain normal until thirty-one days after this treatment was commenced (*Lancet*, ii., 1871).

Shortly before these cases, Dr. Meding, treating rheumatic hyper-pyrexia in a female, aged twenty-two, with enemata of iced water every half-hour, and the application of iced cold cloths, reduced the temperature in five hours from 108.6° to 99.5° F., and the pulse from 140 to 72; no further rise ensued, and no relapse.

Of course, all cases have not been so successful, and Dr. Fox refers to several that ended badly; yet those quoted are sufficient to show the immense power of this mode of treatment, and it has, since that time, been fully endorsed by many English authorities. Dr. Anstie especially pressed its adoption, and Dr. Waters (Liverpool) has recently given good illustrations of its value in two cases of rheumatic fever, one with pericarditis, and both reaching a temperature of 106.7° F., and treated by baths at 95° to 100°, cooled to 70°, and sometimes lower (*British Medical Journal*, i., 1878). In a careful paper, Dr. Ord has given details of the use of graduated cold baths in ten cases of hyper-pyrexia, of which two were fatal (one of these had only one bath, and died eleven days afterward of lung-congestion). In several of the cases, relief to nerve-excitement, and even to bronchial and congestive lung-condition, as well as to pyrexia, was marked; six was the largest number of baths given in any one case. The only contra-indication is excessive weakness. Dr. Ord advocates the systematic early use of this treatment, but also points out the difficulties in thoroughly carrying it out ("St. Thomas's Hospital Report," 1879).

Acute Rheumatism.—I have often given the greatest relief in an ordinary but severe attack, with pain in all joints, sweating, pyrexia, etc., by means of a hot blanket-pack, the patient being enveloped in one blanket wrung out of hot water, and then covered with several others, and left thus for half an hour or more. Dr. Dowse has made scientific observations on this form of bath, and reported much benefit from it (*British Medical Journal*, i., 1875). In the blanket-pack he found temperature rise one to two degrees, and at the same time much sweating produced. He continued it for six hours at first, afterward for one or two hours only; brandy was sometimes required for depression. He did not use this bath when the body-temperature was over 104° F., or the patient

very prostrate, nor when the aortic valves were incompetent. In *chronic* gout and rheumatism the Turkish bath is especially useful.

Puerperal Fever.—In a very striking case reported by Dr. W. S. Playfair, a sheet or towels wrung from iced water were almost constantly applied for eleven days, the patient lying on a water-bed kept cold with running water, and having an ice-cap on the head. By these means only could the temperature be kept under 105°. Eventually the patient was saved, Warburg's tincture having some share in the result (*British Medical Journal*, ii., 1877). Dr. Wiltshire has also reported cases of this disease treated by *dry* cold, *i.e.*, ice packed in bottles and tins near the patient, with temporary good result under unfavorable conditions. Mr. Knowsley Thornton has found an ice-cap, for application to the head only, very useful in keeping down the temperature for ovariotomy.

Typhoid Fever.—Liebermeister, at Basle, systematized the treatment of typhoid fever by cold baths, and his records show a lowering of mortality from 26 per cent. to 7 per cent. So soon as the disease was declared, usually about the ninth day, the treatment was commenced with a bath at 68° F. for ten minutes; this was repeated, not at a fixed time, but so often as the temperature (taken every two or three hours) rose above 102° F. Sometimes six or seven baths were given in twenty-four hours, but commonly a less number. When they acted best an early remission of pyrexia occurred, and lasted for a long period. Quinine in full doses, or digitalis, were often combined with this treatment. Surgensen followed similar practice, and also Bartels, who claimed to reduce his mortality to 3 per cent. There can be no doubt that excellent results may be shown by these physicians, yet the risk of movement and disturbance in cases with serious intestinal lesion must not be ignored, and in the majority of instances other treatment will answer every indication.

Remittent Fever.—A similar method of systematic bathing has been followed with advantage in the remittent fever of the tropics, and Dr. Lucas has recently described a severe case in which the patient (at 103° F.) was lowered into a bath at 80°, and a small continuous stream of cold water was poured over the body for eight minutes. After return to bed the temperature was 97°; quinine and port wine were given. After seven days of bathing—the temperature being kept under 103°—some bronchitis having developed, injections of cold water into the rectum were substituted for the bath, and with very definite effect in lowering temperature; recovery occurred in about a month (*Medical Times*, ii., 1879). In intermittent fever, both Currie and Giannini used cold affusion and bathing with excellent effect, and found that it prevented or delayed a paroxysm if given an hour before its usual access; also that the water-treatment much assisted the action of quinine. Dr. Fleury, however, claims for his cold douche much more than this, stating that he has radically cured by it more than one hundred cases of all forms of inter-

mittent fever, many of them rebellious to all ordinary treatment (including quinine, arsenic, change of climate, etc.), and he quotes evidence on the subject which should receive earnest attention. An energetic cold douche for fifteen or twenty seconds can relieve both the pyretic and the congestive, and also the anæmic condition. For preventing a paroxysm it should be used a quarter of an hour before the expected onset; if this come on before its time, the douche may even be used in the cold stage with good effect, if given strongly for a short time so as to be excitant; if necessary, a second may be given in the hot stage. In irregular intermittents the abdominal viscera are usually congested, and Fleury finds the douche competent to reduce both liver and spleen to their normal size in comparatively short time. Cerebral complications require compresses; pulmonary œdema and acute bronchitis contra-indicate the treatment. In bilious subjects purgatives may be required, or other treatment conjoined.

Scarlatina.—In this fever, some of the very best results of cold bathing and packing have been obtained. In mild cases, tepid or cold sponging during the course of the disorder, and a few carbolized warm baths at the termination are all that is necessary. The warm baths during the period of desquamation help the process, and give much comfort to the patient, especially if followed by inunction of carbolized oil or glycerin. They also stimulate the action of the skin, and lessen renal congestion, or the risk of it, and also the chance of infecting other persons.

Dr. Vaudrey Lush, indeed, and some other physicians, have advocated the routine use of the warm bath from three to five minutes, at first three times a day, afterward less often, for every case of the malady (*Lancet*, ii., 1880); but without denying the advantages of this method, it is clearly often impracticable, and cannot be considered necessary.

In very severe cases, however, when the temperature rises to 104°, 105°, or 106°, F., and there is delirium or stupor, the rash being dark and indistinct, and the urine scanty and albuminous, I have frequently seen, even in apparently hopeless conditions, the cold or hot wet pack bring out a vivid rash, and cause lowering of temperature and abatement of all severe symptoms.[1] Dr. Edison has reported two illustrations of this, occurring in children, with delirium, etc., and both successfully treated by frequent bathing (*Lancet*, 1877); interesting cases treated by cold affusion, also valuable cautions on the subject may be found in Trousseau's "Clinical Lectures" (vol. ii.).

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[1] Although, as above stated, temperature is commonly reduced in the pack, I have known it rise 2° to 3° F. in five different patients in the cold pack, and in four others in the hot pack. At one time I thought such an occurrence to contra-indicate the treatment, but furhter experience has shown me that it does not do so, and I believe that even in the nine cases referred to, recovery was assisted by the treatment.

I first used the *hot* pack in a case of suppressed scarlatina (where the prejudices of parents prevented the usual cold applications), and finding the results equally good, I have commonly adopted it. In the case of a boy whom I found convulsed, and with dusky purplish skin, on the third day of what was presumed to be scarlatina, the hot sheet acted admirably. The throat was much affected, albumen was in the urine, and consciousness was lost. Within half an hour of commencing the hot pack he was able to speak, perspired freely, and the rash came out a vivid red; he was afterward put in blankets, and went on perfectly well without the necessity of repeating the pack. In another still more severe case, the convulsions had lasted over two days, the child was quite blue, there was albumen in the urine, and his life was despaired of; but in the first pack consciousness returned, and recovery followed.

The vapor-bath is another mode of affecting the same results, and is especially applicable when renal congestion and albuminuria are marked, and in such cases compresses, poultices, or fomentations should be kept applied over the loins. The instances given will suffice to show the power of this treatment, although certainly there are cases of malignant scarlet fever which no art can save.

For the *sore throat* of scarlatina, compresses should be used externally. I find it best to have the throat bathed with water as hot as can be borne, for about five minutes every three or four hours, and directly afterward a bandage, wrung out of water at about 112° F., should be applied round the neck and covered with oiled silk. This should be continued for three or four days as an adjunct to other treatment. Dr. H. Corson (U. S.) recommends a piece of ice, in gutta-percha, over each parotid gland. Warm water is a good gargle, or ice may be swallowed in small pieces with much advantage.

In *Measles*, *Small-pox*, and other eruptive disorders, similar treatment by bathing and packing is valuable.

Nephritis.—In acute nephritis from other than scarlatinal causes, warm packing and vapor-baths, and similar means of inducing diaphoresis, are almost equally valuable for relieving the renal congestion and eliminating waste products. In chronic nephritis they act specially as eliminants, and they also lessen dropsy.

Hepatic Congestion.—In acute cases, hot packing over the liver, and in subacute and chronic cases hot mustard-packing and a course of Turkish baths, are highly serviceable.

Catarrhal Jaundice.—Krull has written to advocate the treatment of this malady by the slow injection into the bowel of 30 to 70 oz. of water at a temperature of 60° to 72°. This may be practised for as long a time, and to the extent that the patient can bear it, once in the day: seldom more than seven "irrigations" are required. They are said to relieve gastric troubles, to improve appetite, and quickly cause the reappearance

of bile in the stools. The increased intestinal peristalsis is presumed to induce corresponding contraction in the biliary passages.

Typhlitis—Peritonitis.—The application of an ice-bag, or of iced compresses, in these conditions has often proved more useful than the usual orthodox poultice, and in early stages, the local inflammation and the general pyrexial state may both be relieved by local cold. On the other hand, in some cases a prolonged hot sitz-bath, or smoking hot fomentations, renewed about every half-hour, give great relief. The nausea or vomiting is often quickly checked by administering small quantities of ice or iced water; at other times by hot water.

Diarrhœa.—The abdominal pain of acute diarrhœa is soothed by compresses, poultices, or warm bathing. In children some care is required as to the bath, for convulsions have occurred on placing a child suffering from diarrhœa in a bath at 98° F. This was most likely from an increase in body-temperature under the influence of external heat (Dr. Haddon: *Practitioner*, vol. viii.). The child ultimately recovered, but in such a case the cold sheet would probably answer better.

Cold applications are often more suitable than hot ones in choleraic diarrhœa (McKenna: *Lancet*, ii., 1876), and I agree with Messemer in the experience that cold water enemata act excellently as tonics and astringents in chronic cases. If slowly injected, they distend and keep apart the coats of the bowel, and thus save irritation (*Medical Record*, 1878). I have followed this practice for many years. Wenzel, an experienced naval surgeon, recommends injections of ice-cold water in dysentery, and has found recent acute cases subside quickly under this without other treatment. Fleury gives some remarkable illustrations of chronic dysentery and diarrhœa cured by the systematic use of the cold douche, one patient, aged forty, having previously used many medicinal remedies under able physicians. It is certainly a remedy to be remembered in obstinate cases.

Even in cholera the application of water, warm or cold, may be made highly serviceable. Trousseau wrote strongly in its favor when prejudice against it was greater than it is at present. The stage of collapse may be controlled by a *hot* mustard blanket-pack; but, as a rule, more permanent good will be obtained from *cold* applications. Niemeyer is an authority for recommending the pack with iced sheets in cholera (*Lancet*, ii., 1876, p. 346), and Dr. Chapman has offered evidence in favor of ice-bags to the spine.

Skin Diseases.—In all forms of dry, scaly, skin disease (whether syphilitic or not) warm baths (especially when made emollient and alkaline) and vapor-baths are useful. In acne, hot bathing or steaming opens up the glands and relieves congestion. In psoriasis, ichthyosis, lichen, prurigo, "pityriasis rubra," and chronic dry eczema and seborrhœa, for removing accumulated secretion or preventing contact of air, water com-

presses are serviceable. Hebra has tried the prolonged warm bath for from *two hours* to *nine months* at a time, in some such cases, and in extensive burns, etc., and has ascertained that nutrition, respiration, and secretion go on in the continued bath in a normal manner (*Medical Record*, 1877). On the other hand, in some skins, and especially when the epidermis is removed, as it commonly is in acute eczema, water is apt to excite much irritation.

Cerebral Congestion.—Cold applied to the head, while hot mustard-water is used to the feet, is one of the simplest modes of equalizing the cerebral circulation. It must, however, be used with caution where cerebral anæmia is readily induced, as in weakly subjects. Ice to the nape of the neck also acts well, and sometimes the *alternate* use of cold and hot applications gives the best results. This is especially the case in the congestion of opium-narcosis, uræmia, and carbonic acid poisoning (Bartholow).

Meningitis.—In cerebral or spinal meningitis the application of ice is a valuable resource, but if the face be pale, and there be tendency to chilliness and prostration, it is not suitable.

Sunstroke—"*Thermic Fever.*"—When the head is hot, the pupils contracted, the pulse full, and the temperature high, cold packing is decidedly indicated, also cold affusions, especially to the head.

Delirium Tremens.—When the symptoms are violent and acute, with flushing and heat of head, full pulse, and much restlessness, a cold pack, or, if possible, a douche, or at least an ice-bag or cold compresses to the head, may be very useful in procuring quiet, and even sleep. When much depression or evidence of vascular degeneration exists, such treatment must be employed with extra care.

Insomnia.—This is often dependent upon functional congestion of the nerve-centres, and is amenable to different applications of water. The general tepid bath is suitable for children especially. A cold sitz-bath relieves after intellectual work, or even a cold compress of a folded wet towel placed on the epigastrium, and covered by a dry towel, is often very efficacious. A hot mustard foot-bath, while cold is applied to the head, or a rapid dipping of the feet in cold water and vigorous friction afterward, tend to the same result.

Mental Disorder—Melancholia.—So valuable is the douche-bath in some mental cases that there has been a tendency to overdo this form of treatment, and even fatal results have been recorded from it in cases of extreme depression. It is important not to use it too long at a time. Ten to twenty seconds is sufficient for melancholic cases, and the patient should stand in warm water, so as to secure warmth of the extremities. One or two minutes of a shower-bath, should suffice for excited cases, and often a prolonged warm bath (thirty minutes), while cold is applied to the head, is the most soothing form of treatment. The Turkish-bath

has recently been introduced into asylums, and with some excellent results.

Hypochondriasis.—A course of cold-water treatment, which is at first stimulating and afterward soothing, is useful in this affection. It generally stimulates the vital functions, promotes tissue-change and nutrition, invigorates the skin, and strengthens the physical and mental condition. Other kinds of treatment, however, are often more successful.

Impotence.—When this arises from excess, cold sitz-baths and spinal washings often relieve.

Convulsion.—The reflex convulsions of infancy are often cut short by a warm bath, cold water being poured on the head at the same time (*v.* p. 146). Hysterical convulsion is sometimes arrested by a sudden shock of cold to the surface, and a daily shower-bath is of great service in improving the hysterical state.

In *Chorea* cold affusion, especially over the spine, is very beneficial.

In *Uræmic Convulsion*, this treatment is not so markedly effective, though cold to the head is advisable; but the use of packing, or of the vapor-bath, so soon as the general condition admits, is often of the greatest service.

Tetanus.—Currie, Giannini, and other early observers record benefit from cold applications in tetanus, and illustrations of it have been published by Dr. W. S. Playfair in his Indian experience (*Medical Times*, i., 1862). Of three severe cases of acute tetanus, two were markedly relieved by the application of ice in bladders along the spine; the third was considered too weak for a treatment which is in itself depressant, and this one only ended fatally.

Hydrophobia.—Free action of the skin offers one of the best hopes in this disease, and may be secured by means of the Turkish or vapor-bath. Buisson, a French physician, has recorded that, having become inoculated with the poison of rabies, and feeling the access of the malady, he went into a hot vapor-bath (107° F.) with the intention of committing suicide, but found his symptoms shortly relieved, and by a course of such baths (127° to 140° F.) quite cured. He adds that he has treated many similar cases successfully (*Lancet*, ii., 1877). In a case of Mr. Southam's, which occurred recently at the Manchester Infirmary, a girl was very much relieved of severe symptoms while in a "lamp-bath" and perspiring freely, though a sudden spasm of the larynx caused her death some hours afterward (*Medical Record*, October, 1879).

Paraplegia.—In cases connected with functional disorder of the cord hot, or alternate hot and cold douches to the spine often act very well. Paralyzed limbs that have become cold and wasted may often be much improved by towel-packing and douches, combined with vigorous friction.

Spinal Pain.—The sense of weakness and exhaustion referred especially to the lower part of the spine, occurring in delicate subjects after over-

exertion of any kind, and due probably to a passive congestion, is much relieved by cold "spinal washings," or gentle douching each day for a short time, and followed by good friction. Dr. Moxon has recently drawn attention to the comparatively feeble circulation in the lower part of the cord, and doubtless such remedies act by quickening and regulating the blood-current in that part (Croonian Lectures, *British Medical Journal*, i., 1881).

The more acute backache, commonly felt by women, and in the absence of definite cause traceable often to "anæmia of the cord" (Bartholow), is better relieved by hot applications; and if the douche be not obtainable, then a hot sponge or fomentation will serve.

Therapeutical Action (Internal).— Preissnitz and his early followers combined with the outward application of cold water its immoderate and excessive use internally, an error which led to some evil result, and which is not often now repeated. Water-drinking is now ordered on general dietetic principles rather than as an essential part of a hydropathic course (Braun, chap. v.). In chronic illness good results are more rapidly and easily obtained by the use of *mineral waters* in moderate quantities, and containing salts and gas, so that the number of illnesses in which ordinary water is internally employed as a remedy is not large. Its most common internal use, medicinally, is as a solvent and diluent.

In Fevers of all kinds it is used to lessen thirst, to lower temperature, and restore the balance of fluid constituents of the tissues; also to promote secretion and the elimination of waste products.

Nephritis.—A copious supply of pure water is an effective, non-irritant diuretic, and is very useful in acute renal congestion and inflammation, washing out epithelium and casts from the obstructed tubules. It renders more soluble, also, and helps to carry off, all the products retrograde metamorphosis, and the good effect of many infusions and decoctions is doubtless largely due to the amount of water they contain.

Constipation. — A glass of cold water taken, fasting, in the early morning, will assist in securing a regular action of the bowels. If taken, also, the last thing at night, it has a still better effect. Cold hip-baths are useful for the same purpose.

Hæmorrhoids.—Plentiful water-drinking is indicated in this disorder as a means of relieving the liver by securing a greater flow of bile and accelerating elimination, but a course of aperient *mineral* waters is more effective.

Chronic Metallic Poisoning.—In some cases of this kind, the taking of a large quantity of water is useful by aiding solution of minerals deposited in the tissues, *e.g.*, antimony, arsenic, lead, copper, mercury, etc., or rather their mechanical removal by disintegration of cells. If, however, anæmia be marked, as it often is, this method must be used with care, for fear of impairing nutrition.

Syphilis.—In the later stages of syphilis, or when relapses are fre-

quent, and mercury or iodides are not well borne, hydropathic treatment is a useful resource, tissue-change being promoted by the wet sheet and free water-drinking. Good results are also derived in this disease from the eliminant influence of the Turkish-bath, and the occasional use of this during a mercurial course is always advisable.

Gout—Gravel.—In these cases, hydrotherapy can improve the general condition, and sometimes, it is said, disperse concretions. It promotes lixiviation and increased change of substance, as shown by increase of urea, and renders uric acid soluble. It will not, however, produce the marvellous cures sometimes expected of it.

The dietetic use of *hot water* in gout has been recommended, one or two tumblerfuls of water at 120° being given in the early morning. This is said to regulate the bowels, to cause the disappearance of lithic acid and lithate sediments, and diminish the frequency of acute attacks (Weber). Cadet de Vaux (1825) carried this idea to an extravagant pitch, ordering 8 oz. of hot water (120° to 140° F.) every quarter-hour for twelve hours. Some patients bore this, but others suffered from vomiting, excitement, congestion of the brain, or fever.

The *formation of gravel* is caused, according to Scherer, not by excessive secretion of acid, but by the fermentation of the urine itself, yet the diminution of the secretion of acid must produce a favorable effect; and also the dilution of the urine renders it less irritating to the mucous membrane, and washes away from the membrane, mucus which would produce fermentation. Hence plain water-drinking is good in this condition (Braun), though preference is now commonly given to mineral waters.

SEA-BATHING.

In sea-water the more important saline constituents are the chlorides of sodium and magnesium, and the sulphate and carbonate of lime. Iodides and bromides are contained in minute quantity. Hence the effect of sea-bathing upon the skin and its peripheral nerves is more *stimulating* than that of ordinary water, an effect which is much heightened by the stroke of the waves (Wellenschlag).

The incoming wave beats more upon the upper part of the person, the receding wave upon the lower extremities, providing one of the best forms of douche-bath for such as are strong enough to bear it.

This wave-stroke is naturally more effective in some seas and on some coasts than on others. In the German Ocean (east coast of England) and in the Atlantic (south coast) it is much stronger than in the Baltic or the Mediterranean, and bathing at Cannes, for instance, is not to be compared in bracing effect with bathing at Brighton.

The temperature of the water is an important point in estimating the effect of any form of bath. The temperature of the sea varies less throughout the year than that of rivers: it is highest in the Mediterranean (72° to 80° F.), lowest in the Baltic (60° to 62° F.), and intermediate in the Atlantic (68° to 73° F.). It is higher in autumn than in summer, and hence, September is a good month for sea-bathing, though the wave-stroke is not then so forcible as it is earlier. The temperature of the water is often as much as 12° F. higher than that of the air, and at midday it is several degrees higher than in the early morning.

In considering the influence of sea-water, that of *sea-air* must not be wholly omitted. It contains more ozone, more moisture, and more salt than country air, with less carbonic acid, and usually less dust and foreign admixture; in fine weather the air is more clear and the sun-light more powerful at the coast than inland, and the current of the air is usually stronger and more bracing.

Physiological Action.—On entering the water, under ordinary conditions, a sense of cold is felt; the skin becomes pale and roughened (goose-flesh), the circulation depressed, and the respiration more or less spasmodic; but in suitable subjects this temporary depression is quickly followed by reaction—the skin reddens, the pulse rises and becomes more forcible, while exhilaration and a sense of increased vigor indicate the stimulation of the nervous system. If the bather avoid overtaxing his powers, and will leave the bath before this period of stimulation is passed, he will probably retain, for several hours, a feeling of improved health and general well-being, and it is to such cases that the following statement of physiological results will apply.

Tissue-change is promoted, as shown by an increased excretion of urea and sulphuric acid (Beneke); not that these are immediately or inordinately increased, but the natural healthy maximum is kept up for a much longer time than usual (Ringer). Appetite and digestion are certainly promoted; but if only such a measured amount of food be taken as suffices to maintain the body-weight at a fixed point under ordinary circumstances, *loss* of weight is experienced owing to the increased tissue-change, while if the quantity of food be *increased in proportion to* the improved appetite and digestion, the body-weight is decidedly *increased* by a course of sea-bathing.

The skin-secretion, though at first checked, is afterward promoted: the effect of the first contraction of the skin capillaries is sometimes, if the water be very cold, to determine blood to internal organs, and hence some congestion of the kidneys may occur, and a trace of albumen may be found in the urine; but this condition soon passes off, and the albumen does not persist after the bath.

The urinary water is increased at the time, though it is said that the day's *total* is rather less than normal. The intestinal excretion is usually

lessened, but sometimes increased (Beneke), and either constipation or diarrhœa may be induced.

Restlessness and sleeplessness are more serious symptoms occasionally caused, but in my experience as much by a residence on the *sea-level* as by simple bathing. The hot, strongly saline baths, as at Droitwich, do, however, often induce an extreme degree of restlessness, and should not be used too frequently.

It is worth noting that the long hair of women, when often soaked with salt-water, may fall off, but it quickly grows again.

THERAPEUTICAL ACTION.—Sea-bathing tends to "harden the skin," to moderate undue perspiration, and to diminish the tendency to catching cold and to rheumatic attacks. It acts as a general stimulant in all conditions of constitutional debility, and also as a local stimulant, promoting absorption and improving circulation.

In *Chronic Forms of Nerve-Disorder* with depression, and hypochondriasis, sea-bathing is often very beneficial through a strongly stimulant action on the peripheral cutaneous nerves: by its influence on tissue-change it is said to benefit, not only in functional disorder, but even after material change in the nerve-substance (Husemann).

Struma, etc.—In various forms of struma, scrofula, and chronic conditions of blood-poisoning, sea-baths are indicated, and during convalescence from fevers and other acute disorders, or after prolonged town-residence or town-work, they have an excellent effect.

Sprains, etc.—As a remedy for the effects of *sprain* or of *injury to joints*, or of *spinal weakness*, douches of hot and cold sea-water are exceedingly useful.

Recently gargles of the same are said to have proved curative in chronic relaxed conditions of throat, "Clergyman's Sore Throat," etc. (*British Medical Journal*, July, 1879).

TIME OF BATHING.—To bathe before breakfast is the custom of some robust persons, but is never free from risk, and sometimes seriously injures weakly subjects: for after the long fast of night the circulatory and central nervous organs are more liable to depression from sudden shock or over-fatigue. On the other hand, to bathe soon after a meal arrests the process of digestion, and may give rise to very unpleasant gastric and cerebral symptoms. The best results are obtained from bathing two or three hours after the early morning meal, when the stomach is nearly empty, and there should be at least a brief interval of rest or of but moderate exercise, according to the weather, between the bath and the following meal. The object aimed at being a marked and prolonged reaction, this is best obtained from a bath taken during a condition of the greatest nutritive and functional activity, when the work of the stomach is over and the blood is enriched by the products of digestion.

ERRORS IN BATHING.—The good effects already described as proper

to sea-bathing may be missed, and very unpleasant symptoms may arise, if attention be not given to certain points.

The therapeutical object is to secure and sustain a good *reaction*, and this is impaired if the bath be too cold, or too prolonged, or if excessive exertion be taken before, during, or after it, or if the patient be under the influence of strong emotion, as a nervous, frightened child would be. The most common errors are to prolong the bath unduly and to exert one's self overmuch during it: the sense of vigor is then replaced by exhaustion, the skin again becomes cold, and the circulation depressed; giddiness and headache occur from altered conditions of the circulation, with general malaise, and possibly shivering, nausea, sickness, and a sense of depression lasting for many hours. It is therefore important to leave the bath before the stage of reaction and stimulation is finished. With some persons the stroke of three or four good waves is sufficient for the best results, five minutes is an average time for the delicate to remain in the water, and no one bathing for *health only* should remain in the open sea for more than ten minutes.

Contra-indications.—At the extremes of life, sea-bathing in the open should be practised cautiously. As a rule, it is unsuited for children under two years of age, or for patients over sixty. Pregnancy in healthy subjects need not prevent the use of salt-baths, or sea-bathing, provided that the patient is accustomed to a cold-bath previously, but as a rule, the various inconveniences of open-air bathing render its risks greater than any advantage in that state. The tendency to cause congestion, more or less temporary, of internal organs, the brain, liver, lung, or kidney, renders open-air sea-bathing unsuitable for persons disposed to such disorders, or suffering from structural change or marked blood-stasis within the abdominal organs, albuminuria, serious cardiac disease, chronic pneumonic infiltrations, hæmoptysis, fatty degeneration, or rheumatism which is at all acute. An extreme degree of anæmia is a contra-indication.

MINERAL WATERS AND BATHS.

The so-called *mineral* waters are really medicines, largely diluted and complex, containing various salts and gases derived from the soils through which they pass, and administered at varying temperatures, generally warm.

Physiological Action.—Applied *externally* in the various forms of bath, they act like the plain water-baths already described, with special powers of stimulating the skin, and indirectly the visceral circulation, or of quickening absorption and lessening pain.

Given *internally*, they act by promoting tissue-change, secretion, and

excretion, thus diluting and depurating the blood, and increasing the bile and other organic liquids. "Critical eruptions and discharges may occur during their administration, but are not advantageous."

Their action is not to be explained solely by the proportion of ingredients recognized by an analysis—*e.g.*, 1½ dr. of magnesia sulphate has far more purgative effect when taken in the form of a natural water than when dispensed by a chemist, and hence, although imitated, they cannot be quite replaced by artificial combinations.

Therapeutical Action.—Mineral waters are mainly used in *chronic* functional disorders, and in conditions of debility and convalescence, but are suitable also for early stages of organic disease. In estimating their effects, allowance must be made for the change of climate and surroundings, and the more regular, simple, and quiet life of a Spa. Hence the drinking of imported waters at home will not give the same result as taking them at their source.

Season.—The usual season for drinking the mineral waters includes summer and autumn, *i.e.*, extends from May or June to September or October, and the duration of a course is from three to six weeks. Too prolonged continuance of the treatment is liable to do harm.

Dose and Mode of Administration.—It must be recognized that benefit is not derived in proportion to the quantity of water taken: at first only small quantities daily are desirable. Bathing and drinking should not be commenced on the same day. When the strength permits, early rising is advisable, so that the water may be taken before breakfast; it should be sipped slowly, and an interval allowed for a gentle walk between each glass. The diet should be carefully regulated—it is usually less generous abroad than in this country. As a rule, some physician resident at the Spa should be consulted.

CLASSIFICATION.

Braun, in his excellent treatise (edited by Dr. H. Weber, 1875), classifies "Mineral Waters" somewhat as follows:—

Class 1—Carbonic Acid Waters comprise many of various character, more or less impregnated with this gas, which renders them easier of digestion, and *chemically* assists the solution of bicarbonates, *e.g.*, of soda and iron. Their *medicinal* properties are, to lessen gastric irritability, to stimulate slightly the secretions of the stomach and of the kidneys, and to increase the peristaltic action of the intestines.

There are a few springs which contain only a small amount of saline ingredient with so much *gas* that they may be called *simple acidulated or carbonated waters*, but none of these are active enough to be in demand beyond their own locality. All the commonly used aërated waters con-

tain a notable proportion of alkalies, chlorides, earths, or iron, and hence, although containing carbonic acid, find their place rather in the following classes.

CLASS 2—SALINE WATERS.

(*a*) *Simple Alkaline Waters* (containing carbonate of soda as a main ingredient), are such as those of Vichy and Neuenahr, Salzbrunn, Mont Dore, Bilin, Gieshübel, Apollinaris, etc.

(*b*) *Muriatic Soda Waters* contain in addition sufficient *chloride of sodium* to correct the dyspepsia or debility sometimes induced by a *pure* soda water, and are those of Luhatschowitz, Ems, La Bourboule, etc. (*v.* pp. 158, 159).

These and the preceding waters are ordered in cases of acid gravel, gout, venous stasis, and abdominal obstruction, in scrofulous exudations, in diabetes, and in chronic catarrh of the respiratory, gastric, or genito-urinary tract. In catarrh especially, waters containing chloride are to be preferred.

(*c*) *Bitter Waters* ("purging saline waters") containing sulphate of soda and magnesia as chief ingredients are such as Friedrichshall, Hunyadi Janos, Püllna, Seidlitz, Epsom, Beulah Spa, Purton, Cheltenham, Leamington, Scarborough (*v.* pp. 159–161).

One or two wineglassfuls of these waters (preferably taken warm) stimulate the gastro-intestinal mucous membrane, and produce a watery discharge from its glands. They are useful in habitual constipation, especially when this is connected with torpor or congestion of the liver; but if given too frequently, or in excessive dose, they are apt to bring on flatulence, dyspepsia, or intestinal catarrh in delicate subjects.

(*d*) *Compound Soda Waters* (containing sulphate of soda in effective doses) are Carlsbad, Marienbad, Franzensbad, Tarasp, etc. (*v.* pp. 161–163). These are ordered in gout, gravel, diabetes, and catarrh, like the simple soda waters, and also more especially in dyspepsia, corpulence, jaundice, gall-stones, and hyperæmic enlargement of the liver, and in hæmorrhoids occurring in plethoric persons. These waters, if freely used, are markedly lowering in their action.

(*c*) *Common-Salt Waters* include those of Homburg, Kissengen, Baden-Baden, Wiesbaden, Reichenhall, Kreuznach, Harrogate (*v.* pp. 163, 168).

These waters are used, taken cold and in but moderate quantity, in dyspepsia and gastric catarrh; also in constipation and chronic intestinal catarrh; for early stages of abdominal plethora, and for hæmorrhoids and venous stasis occurring in thin depressed subjects; also in bone disease and scrofulous exudations, inflammatory effusions, and glandular and even fibroid tumors.

CLASS 3—SULPHUR WATERS, which contain alkaline sulphides or sulphuretted hydrogen, are found at Aix-la-Chapelle and Aix-les-Bains,

Weilbach, Barèges, Luchon, Cauterets, Harrogate, Llandrindrod, Moffat, Lisdoonvarna, etc. (*v.* pp. 168–172). They are used for chronic syphilitic and scrofulous disorders, bronchial catarrh and phthisis, chronic hepatic congestion, chronic rheumatism, and metallic poisoning, such as that from lead or mercury. The digestive powers are liable to be taxed by a course of these waters, and more or less anæmia is apt to follow. Good meat diet is desirable while sulphur is being taken.

Class 4—Earthy Mineral Waters (containing a large proportion of lime).—Rehme, Eilsen, Leuk, Weissenburg, Wildungen, etc., and many other waters, contain a small proportion of carbonates of lime and of magnesia (*v.* pp. 172–174). The special springs named are used in vesical catarrh and uric acid concretions, in gouty and scrofulous exudations and skin diseases, also in bronchial catarrh and phthisis. Separate classes are made by some authors, *e.g.*, of the *iodo-bromated* waters at Kreuznach and Woodhall, and the *muriated lithia* waters of Baden-Baden.

Class 5—The "Indifferent" Waters of Leuk, Gastein, Wildbad, Schlangenbad, Buxton, etc., are used almost wholly in the form of *bath* in cases of rheumatism, paralysis, and other nervous disorders (*v.* pp. 174–176).

Class 6—Chalybeate Waters, those in which iron carbonate is the main ingredient, are such as Spa, Schwalbach, Tunbridge Wells, Driburg, Pyrmont, Harrogate. The sulphate occurs in springs at Brighton and at Sand Rock (Isle of Wight); the perchloride in a spring at Harrogate (Muspratt's).

These waters are used in chlorosis, direct anæmia, irregularities of menstruation, atonic conditions of the stomach and intestine, in general debility, and in various neuroses. Care is required to secure their due absorption without dyspepsia. The general rules for iron-medication are further indicated in the chapter on that remedy.

A knowledge of Spas and mineral waters is so necessary in modern practice that a more detailed, though necessarily brief, account of the principal ones is subjoined.

CLASS 2 (a).—SIMPLE ALKALINE WATERS.

Vichy, in central France, seven hundred and eighty feet above the sea, is situated on the River Allier, in a large open valley surrounded by vine-clad hills; the climate is mild, the season is from the middle of May to mid-September. The arrangements are on a magnificent scale, and the Spa is the most frequented in Europe (Braun).

The springs used are nine in number, all clear, warm, and tasting more or less like soda water; they contain from 36 to 39 gr. of bicarbo-

nate of soda in each pound (16 oz.), from 12 to 14 cub. in. of carbonic acid, and small quantities of chloride of sodium (4 gr.), of bicarbonate of potash, and of magnesia, and arseniate of soda.

They may be used in any case in which strong alkaline waters are indicated, and either for bathing or drinking, or both. The *Grande Grille*, which has a temperature of 113° F. is in most repute, especially for hepatic disorders, the *Celestins* for urinary maladies, and the *Hôpital* for abdominal stasis, chronic enteritis, etc. The *Hauterive* is cold, and contains an unusually large amount of carbonic acid.

The most suitable cases for Vichy are those of uric acid gravel and calculus, gout, vesical catarrh, and diabetes of the slow and less pronounced kind. But besides these, a large number of other maladies are treated there with more or less success—such as dyspepsia, gastric catarrh, enlargement of liver and spleen, abdominal congestions, chronic metritis, and chronic rheumatism. The dose of the water is from half a pint to two pints daily.

Vals, in the southeast of France (Department Ardèche), is an important Spa with cold alkaline springs, similar in composition to the waters of Vichy. The principal ones, *Précieuse*, *Désirée*, *Madeleine*, and *Rigolette*, contain rather more bicarbonate of soda and carbonic acid and iron. The two former, slightly laxative, are employed in gouty and renal disorders; the two latter are more roborant. *St. Jean* is less alkaline, and is ordered for dyspepsia; *Dominique* is arsenical. The waters of Vals and Vichy are largely exported.

Neuenahr, in Rhenish Prussia, three hundred feet above the sea, in the mild and beautifully wooded valley of the Ahr, is easily reached from Cologne. It has excellent buildings and public gardens, and is rising in estimation. It possesses a cold spring rich in carbonic acid, and four warm springs—93° to 104° F.—each containing about 9 gr. in the pound of bicarbonate of soda, with a small proportion of lime and magnesia, much carbonic acid, very little chloride of sodium or iron.

Bilin, in Bohemia, and *Fachingen*, in the valley of the Lahn, contain strong soda springs, which, however, are but little used on the spot, though they are exported in large quantities. The water of Bilin contains 33 gr. of bicarbonate in the pound, with chloride 2 gr., and sulphate 6 gr., lime 4 gr., a trace of iron, and much carbonic acid, at a temperature of 53° F., and generally requires to be heated. That of Fachingen is very similar, but somewhat weaker. Both are used for severe cases of gravel, gout, and vesical catarrh.

The water of *Gieshübel*, near Carlsbad, contains a small proportion (10 gr. to the pound) of bicarbonate of soda, with a large amount (55 cub. in. to the pound) of carbonic acid. It is pleasant and refreshing, and exerts a moderate antacid effect.

Apollinaris water, from a spring of that name, situated near Neu-

enahr, in the valley of the Ahr, contains about 10 gr. of bicarbonate of soda, 3 gr. of chloride, 2 gr. of sulphate, and 3 gr. of magnesian carbonate, with a large amount of carbonic acid to the pound, so that it may be warmed without losing its pungency.

It is useful as a table water in irritable conditions of the stomach, and as a medicinal water in the lithic acid diathesis and gout; also in bronchial catarrh and tendency to gall-stone.

Salzbrunn, in Silesia, near Freiburg, situated in a wooded valley twelve hundred feet above the sea, has a fresh bracing climate, and has soda waters with about 18 gr. of bicarbonate in the pound (16 oz.). It has been called "the cold Ems," and has been especially recommended in bronchial catarrh and in early stages of consumption when Ems is not suitable. A much frequented establishment for the "whey-cure" and "moor-baths" is also to be found at Salzbrunn.

Mont Dore lies in a charming valley of the Auvergne Mountains, thirty-three hundred feet above the sea, and possesses a cold and several warm soda springs (106° to 108° F.). They contain only about 5 gr. of bicarbonate to the pound, but more chloride of sodium than those yet mentioned, also an excess of carbonic acid. The *Madeleine* is also arsenical. The Spa is well provided with appliances for separate baths, douches, sprays, and inhalations, and has a reputation in chronic pulmonary catarrh and asthma, and in chronic hepatic congestion and rheumatism. "Most invalids employ warm bathing, the effect of which is to increase perspiration, and after some days to induce a 'bath fever,' with lassitude, constipation, etc., but this soon passes off." It has a reputation for benefiting and often curing emaciated broken-winded *horses* with bad coughs. It has been recently proposed to introduce all the resources of Mont Dore into an English establishment at Bournemouth.

CLASS 2 (b).—MURIATIC SODA WATERS.

Ems, near Coblenz, in the valley of the Lahn, two hundred and ninety-one feet above the sea, is the oldest and most famous soda spring. It is conveniently reached from England, has excellent hotels, and English-speaking physicians. The valley is narrow, between high mountains, with attractive scenery, and possessing a mild climate. "There are few bathing resorts where a sick person may find in intercourse with nature and man, and in the enjoyment of a brilliant but unpretending Spa-life, such rich opportunity both for coming out of himself, and for self-reflection. Ems is the pearl of Germany" (Braun). Cases of phthisis, however, should not be sent there, as by day the air is hot and still, and in the early autumn, mists at night and morning are frequent. The best months are May and June, September and October. During July and August, when many English people go, the climate is likely to be found oppres-

sive and relaxing. The mineral springs contain a medium amount of bicarbonate of soda (10 gr.), and of carbonic acid (19 cub. in.), and of chloride (7 gr.), with very small amounts of lime and magnesia.[1] The main difference between the springs is in temperature, the *Kranchen* being at 84° F., and the *Kessel* at 114° F. They are often given with goats' or asses' milk, and are used for chronic bronchial disorders with irritable cough but little secretion; in the dyspepsia of persons disposed to phthisis; and for eczema and prurigo; also for lithuria, though less often than those of Vichy.

The baths at Ems are much used. The well-known *Bubenquelle* is a warm ascending vaginal douche, which has a reputation in inflammatory and engorged conditions of the uterus.

Luhatschowitz (in Moravia) is situated in a pleasant valley of the Carpathian Mountains, sixteen hundred feet above the sea. The springs, four in number, are cold, and contain in each pound from 30 to 60 gr. of bicarbonate of soda, 20 to 30 gr. of chloride of sodium, with traces of iodide and bromide of soda, and a large amount of carbonic acid (Braun). "They are the ideal of strong carbonated muriatic soda waters," and are valuable in severe catarrhal conditions, especially in chronic gastric catarrh, and in abdominal congestion and gouty exudations. In cases of hyperæmic enlargement of the liver, they even come into competition with Carlsbad water, and in cases where the strong soda waters of Vichy, Biiin, etc., have failed in their effect, it is well worth while to try a water containing more chloride; this salt increases the effect of the carbonate. Whenever tissue-change is to be increased, and at the same time tissue-growth promoted, and the gastro-intestinal secretions stimulated, soda waters containing common salt are to be preferred.

La Bourboule, in the Auvergne district, two thousand six hundred feet above the sea, has several springs of different temperatures and proportions, but all containing carbonate and chloride of sodium, and also appreciable quantities of arsenic.

CLASS 2 (c).—BITTER WATERS.

The Friedrichshall water, which is largely imported from a spring in Saxe-Meiningen, contains, in a pound, sulphate of soda 46 gr., sulphate of magnesia 39 gr., chloride of sodium 61 gr., chloride of magnesium 30 gr., and sulphate of lime and potash, with a small amount of carbonic acid (Liebig). This water is useful in small non-aperient doses for promoting tissue-change, and in aperient doses is frequently prescribed for habitual constipation, hepatic congestion, abdominal plethora, etc.

[1] In this and all the following analyses the quantities are calculated for a pound of water (16 ounces).

The Hunyadi Janos waters are the richest bitter waters yet known. Sixteen ounces contain 138 gr. of sulphate of magnesia, 129 gr. of sulphate of soda, with 11 gr. of chloride, and 13 gr. of carbonate of soda. They are used in the same class of cases as those last mentioned, but are more active and are rather less unpleasant to the taste.

Pällna water is of the same character, but intermediate in strength between Friedrichshall and Hunyadi Janos, containing 123 gr. of sulphate of soda, and 93 gr. of magnesia, with carbonate of the same, and chloride of sodium.

Seidlitz contains no sulphate of soda, but 104 gr. of sulphate of magnesia.

The once famous *Epsom* well contains in the pound 240 gr. of sulphate of magnesia, to which it has given its name.

The Beulah Spa (Norwood) contains 61 gr. of Epsom salt, with 9 gr. of soda sulphate, and some chloride.

The Streatham and *Kilburn Wells* resemble the Beulah Spa.

Purton Spa, near Swindon, has 23 gr. of each sulphate, together with chloride, lime sulphate, and some carbonic acid (which is deficient in most waters of this class); also traces of bromides, iodides, and sulphuretted hydrogen. This water is used as an "alterative stimulant" in strumous sores and enlarged glands, threatened consumption, hepatic disorders, rheumatism, chronic skin-disorders, and uterine derangements. Half a pint to a pint of the water is taken before breakfast, and another half-pint in the evening. The air of the place is dry and bracing.

Cheltenham possesses saline springs of several qualities. That of the *Royal Old Well*, first noted for the cure of George the Third, contains chiefly chlorides of calcium, sodium, and magnesium, with sulphate of soda and a little carbonic acid.

The Pittville Saline contains an unusual proportion of *silica*. *Spring No. 4, Montpellier*, contains a large amount of common salt (52 gr. in the pint), with 17 gr. sulphate of soda, and 14 gr. of magnesia, but is deficient in carbonate of soda and carbonic acid. This might be remedied, as Dr. Macpherson suggests, by adding a certain quantity of Bilin or of Vals water, and the temperature might be graduated, and very useful results again obtained from these waters. The *Montpellier* baths are well arranged, and include vapor douches and medicated vapor baths.

In winter the mild and equable, though rather moist climate, would even give an advantage over more distant Spas. By the Cotswold Hills the town is sheltered from north and east winds. The season is from mid-April to October.

At *Leamington*, the saline spring *Old Well*, contains in the pound 40 gr. of soda sulphate, 40 gr. of sodium chloride, 20 gr. of calcium chloride, 3 gr. of chloride of magnesium, traces of bromine and iodine, and 2 cub. in. of carbonic acid; also nitrogen and oxygen; temperature, 48° F.

These waters are alterative, and are slightly aperient, more active than those of Cheltenham, and hence suitable for invalids of "torpid habit." I have used them with advantage in hepatic derangement.

The town is clean and pleasant, less protected by hills than Cheltenham, and hence the air is rather colder and more bracing; it is humid, but not raw.

At *Scarborough*, the *South Well* contains 28 gr. of sulphate of magnesia with 13 gr. of sulphate and 6 gr. of carbonate of lime, some common salt, and a trace of iron. The amount of lime is rather too large for cases requiring purgative waters.

CLASS 2 (d).—COMPOUND SODA WATERS.

Carlsbad, in Bohemia, situated on the banks of the Töpel, in a narrow valley twelve hundred feet above the sea, is one of the principal, as it is the oldest of German Spas. The season is from the end of May to the end of September; at other times the climate is "rough," though in May it is often not more than fresh and bracing. Among the advantages of Carlsbad, Braun reckons the careful diet, and among the disadvantages "an excessive use of coffee." The valley is rich in warm springs, which differ little in their fixed constituents though much in their temperature and gaseous contents. The *Sprudel*, which forms a fountain several feet high, giving off clouds of vapor, has a temperature of 164° F., contains 11.8 cub. in. carbonic acid, and sulphate of soda 18 gr., chloride 7 gr., carbonate 10 gr., with a little lime, magnesia, and iron. The *Schlossbrunnen* at 124° F. contains 17 cub. in. carbonic acid. The *Markbrunnen* at 130° F. contains in addition some iodide and bromide of sodium.

Carlsbad waters are efficacious in several forms of dyspepsia, *e.g.*, when gastralgia and flatulence occur principally after meals, and when catarrhal conditions of the stomach or intestine are present, and morning vomiting, or diarrhœa alternating with constipation. For corpulence, with its various troubles, they are a tolerably sure and gentle remedy, independently of violent evacuations. In jaundice, and a tendency to gall-stones and allied conditions, the waters diminish the inflammation and tumefaction in the gall-ducts, and thus enable calculi to pass more easily. In hepatic and splenic enlargement following malarial fevers, especially if constipation be marked, and in passive hyperæmia of the portal system and abdominal viscera occurring in stout florid persons with a tendency to hæmorrhoids, and generally sluggish venous circulation, Carlsbad waters are very effective. "Old Indians with enlarged livers often derive remarkable benefit." The hypochondriasis dependent more or less on the above-named conditions is also relieved. In gout and gouty conditions without much joint-affection, especially in patients with abdominal plethora and commencing atheromatous change in the vessels, in rheumatoid

arthritis, sciatica, and in the tendency to uric acid concretions and consequent catarrhal affections of the urinary organs, Carlsbad waters are often quite as useful as the stronger alkaline waters. In cases of the *slower* and *milder* form of diabetes, the use of Carlsbad waters has rapidly and considerably diminished the excretion of sugar, and after some months has effected great improvement in the general condition in many instances. Even in serious cases, provided they are not very acute and rapid in their onset, and not accompanied by phthisis, the same waters have often effected an improvement, and checked the progress of the disease.

In these observations I find myself in agreement with Seegen and Braun, and have only to add that the course at Carlsbad need not, and should not, be so conducted as to "purge, lower, and starve" the patient. We sometimes hear complaints of the depression and debility induced, and certainly, an excessive use of the waters is very lowering, but effective therapeutical results may be obtained without this. The diet, though restricted, should be nourishing, exercise moderate, not exhausting, and mental and bodily rest for some time after the treatment is very desirable. Baths of the cooled mineral waters are often beneficial, but are less used now than they formerly were.

Marienbad, also in Bohemia, and about five hours' drive from Carlsbad, is situated in a broad and beautiful valley, about nineteen hundred feet above the sea. The air is not mild, but is pure and dry, "and colds are less often taken here than at Carlsbad." The season begins somewhat earlier, viz., at the beginning of May, and it lasts until the end of September. Marienbad is the principal representative of cold gaseous sulphated soda waters, and the springs most used, the *Kreuz* and the *Ferdinandsbrunnen*, are stronger than the Carlsbad springs, and contain more free carbonic acid. They are more aperient, and given therefore in smaller doses (one to six tumblerfuls), or to patients who need more purging. In other respects, and excepting in diabetes, these waters are used like those of Carlsbad. They contain some iron, which, however, is not of importance, unless in the *Kronprinz-Rudolf* spring.

The *Carolinen* and *Ambrosius* springs are gaseous, weak in saline constituents, but containing some iron. The *Marienbrunnen* is used for drinking as well as for water and carbonic acid baths. The *Moor* or *mud-baths* at this Spa are also in request, and are prepared with black mineral powder brought from a neighboring peat-bed. The *gas-baths* relieve myalgic and neuralgic pain, and soothe the *general* nervous system, while they stimulate that of the uterus; the *mud-baths* stimulate the skin and promote the healing of ulcerations, and the absorption of glandular swellings.

Franzensbad, near Edgar, in Bohemia, thirteen hundred feet above the sea, has a fresh climate and good arrangements. The waters resem-

ble those of Carlsbad, but are colder, and have more carbonic acid, and also more sulphate of soda (18 to 27 gr., with chloride, carbonate, and some iron). The treatment at this Spa has always been milder and more stimulating than at Carlsbad, and better adapted for anæmic, weak, thin, and perhaps hypochondriacal or hysterical subjects. In such cases, and especially in women who have become anæmic with spinal irritation and uterine disorder, benefit is obtained here when stronger and more pronounced chalybeates would not agree. Digestion is promoted, the nervous system strengthened, and the circulation stimulated.

Mud and gas baths are also much used here, and are beneficial in chronic skin disease and ulceration, rheumatism, gouty deposits, and paralyses when no active central disease is present.

Tarasp, in the Lower Engadine, canton Grisons, situated on the River Inn, amid fine Alpine scenery, four thousand feet above the sea, has recently risen into fashion, and is one of the most interesting and valuable Spas. The rarefied pure air acts as a powerful stimulant or tonic, and the summer climate is temperate and pleasant, while the conditions of life are much more simple than at Carlsbad, Vichy, Marienbad, etc. The ingredients of the waters are the same as those of Franzensbad, Marienbad, or Carlsbad; the chief springs are the *great*, or *St. Lucius*, spring, and the *little*, or *St. Emerita*, spring, having 16 gr. of soda sulphate, 29 gr. of chloride, about 40 gr. of bicarbonate, 17 gr. of lime, 7 gr. of magnesia, an effective proportion of iron, and a large amount of carbonic acid.

These are used in the cases already described as suitable for Carlsbad and Marienbad, except that there is not yet an equal experience as to diabetes; on the other hand, cases of bronchial catarrh, and even of tuberculosis in an early stage, and especially when complicated with hepatic troubles, have derived much advantage at Tarasp.

CLASS 2 (c).—COMMON-SALT WATERS.

Homburg, in Prussia, about nine miles from Frankfort, pleasantly situated on the southern slope of the Taunus Mountains, six hundred feet above the sea, has a fresh and bracing climate even in the summer. The *Elizabethbrunnen* (the most-used spring) contains 75 gr. of chloride of sodium, the *Kaiserbrunnen* 55 gr., while both have also other alkaline chlorides, lime, magnesia, a little iron, and much carbonic acid, at a temperature of 50° F. (cold). The *Ludwigsbrunnen* contains only about half the amount of chlorides, and the *Luisenbrunnen* scarcely any calcium or magnesium.

The two springs first named are stronger than those of Kissingen, and are given in doses of two to four tumblerfuls in cases of dyspepsia and gastro-intestinal catarrh, constipation, strumous glandular enlargement,

gout, obesity, hypochondriasis, etc. The *Luisenbrunnen* is "very suitable for anæmia and Indian cachexia."

Kissingen, about thirty miles from Würzburg, and six hundred feet above the sea, in the pleasant valley of the Saale, is the main representative of cold, moderately strong gaseous salt springs, and is one of the most fashionable watering-places of Germany. The principal springs are the *Ragoczi*, the *Pandur*, and the *Maxbrunnen;* the latter is a very weak salt water; the other two are nearly equal in strength, containing more than 40 gr. of chloride of sodium with small quantities of other alkaline chlorides, 4 gr. of sulphate of magnesia, 2 gr. of lime, a trace of iron, and much carbonic acid (40 to 48 cub. in.); the temperature is 51° F. (cold). The *Ragoczi* is generally taken in the morning (three to six glasses); the *Pandur*, being somewhat milder, in the evening. They quicken the circulation, alter and stimulate the gastro-intestinal secretions, and are valuable in dyspepsia, with eructations, flatulence, and constipation, in some gouty and calculous cases, in moderate degree of hepatic and renal congestion, in strumous and tubercular enlargement of glands, etc.

In prescribing salt springs for cases of chronic dyspepsia, we should bear in mind that, as a rule, they are best taken *cold*, because a high temperature counteracts the intended irritant effects, and causes too rapid absorption of the salt. They are unsuitable for cases of excessive acidity which is increased by chlorides. The water should not be concentrated, and the dose should be small, and carbonic acid much assists its digestion. On the other hand, in some cases of gastric catarrh, the cold waters are not well borne, and then recourse is had to the *warm* spring of Wiesbaden. The strong salt bath of the *Soolsprudel* is much used, but Braun objects to the large amount of carbonic acid given off from it and inhaled by the lungs, as being apt to cause giddiness and dyspnœa.

Wiesbaden, capital of the former Duchy of Nassau, is three hundred and twenty-three feet above the sea, and is situated beautifully on the southern slope of the Taunus Mountains, five miles northwest of Mayence. The climate here is mild, in winter being one of the warmest in Germany; in spring and autumn usually fine; but at midsummer hot and relaxing. The season is from June till September. The principal spring is the *Kochbrunnen*, which rises like a boiling well at 150° F., emitting clouds of steam. Its constituents are similar to those of the Kissingen *Ragoczi*, viz., chloride of sodium (52 gr. in the pound), carbonate of lime (3 gr.), and traces of potash, magnesia, iron, etc. The amount of carbonic acid is much less (6 cub. in.); the temperature much higher. The amount of chloride is slightly greater than that at Kissingen, but yet larger doses of the water can be taken, and increased intestinal secretion less often occurs from it. Hence if the gastric condition does not espe-

cially need the stimulus of cold, the warm spring is to be preferred when the strong effect of salt on the blood is desired.

In cases of chronic inveterate gout which we can scarcely hope to *cure*, but which we can benefit by moderate increase of tissue-change while keeping up nutrition, these springs are most useful. They are useful, also, in chronic eruptions with hepatic and abdominal congestion, and in chronic rheumatism, in which disorder and in chronic paralyses the warm saline baths are specially indicated.

They may be injurious in debility, in uterine congestion, and in tendency to apoplexy or other hemorrhagic conditions.

At Wiesbaden there are also hydropathic establishments, and the ophthalmic hospital of Dr. Pagenstecher.

Baden-Baden, six hundred and sixteen feet above the sea, is situated in a beautiful valley of the Black Forest, six miles from the Rhine. The air is pure and mild, so that baths can be taken late in the autumn, and the season is from the beginning of May until October. The general arrangements are agreeable, and the influx of visitors very large. Of the numerous springs, only the *Ursprungquelle* need be mentioned. It contains 18 gr. of chloride of sodium, and 2½ gr. of lime sulphate, with traces of iron carbonate, but very little free carbonic acid.

Gout and rheumatism of only moderate severity, dyspepsia, and impaired nerve-condition from overwork, etc., various manifestations of the scrofulous diathesis, are all favorably influenced by the waters of Baden-Baden, which are taken internally and used as baths.

Soden, in Nassau, near Frankfort, four hundred and forty feet above the sea, contains many tepid salt springs varying in their proportion of chloride from 18 to 109 gr. The amount of carbonic acid is rather large.

The climate is mild, equable, and moist, but very hot in summer. Besides being suitable for the class of cases already mentioned, Soden has a special reputation in chronic catarrhal conditions, with or without tendency to phthisis. Near at hand, at Kronthal, are good chalybeate springs, and the bracing health-resort of Falkenstein, which is seventeen hundred feet above the sea, well wooded and sheltered from excessive sun and wind, and forming a good residence both in winter and summer for the earlier stages of phthisis.

Reichenhall, in Bavaria, lies in a sheltered position, near fine Alpine scenery, and has a mild climate, at its best in May and autumn—rainy in the summer. Of its salt springs, the *Edelquelle* is one of the strongest in Europe, containing 23 per cent. chloride of sodium, temperature 57° F. The waters are used in warm, tepid, douche, and wave-bath, and also by inhalation, patients walking between large hedges, forty feet high, made of twigs, on which the salt water trickles and evaporates: the air of a large room is also kept impregnated with salt spray; and the breathing of such air for a limited period daily is found useful in catarrhal conditions

of the chest and stomach (Burdon Sanderson: *Practitioner*, vol. i.). There are similar chambers at Kreuznach, Rehme, and a few other places.

Kreuznach, in Rhenish Prussia, pleasantly situated in the Nahe Valley, two hundred and eighty-six feet above the sea, "is the chief of sool-baths" (Braun).

The climate is mild in the early spring and late autumn, hot in the summer. The season extends from the end of April until the beginning of October. The *Elisenquelle*, or *Elizabethbrunnen*, contains 73 gr. of chloride of sodium, 13 gr. chloride of calcium, 4 gr. chloride of magnesium traces of potassium, lithium, iron, and minute quantities of bromide and iodide of magnesium. There is some carbonate of lime but no sulphate; no carbonic acid. Temperature, 54.5° F.

The water of the *Carlshalle*, and *Theodorshalle* is weaker, the chloride of sodium being 59 gr. and 57 gr. respectively, while the *Oranienquelle* has 108 gr. of the sodium salt, and 22 gr. of chloride of calcium. The waters, which are bitter and rather nauseous, should be commenced in small doses, and are often taken with hot milk. The *Elisenquelle* readily acts on the bowels.

The warm baths at Kreuznach are used particularly strong, concentrated brine, or "mother-lye," being often added to the natural water, and the bath being prolonged for half an hour or an hour. This "mother-lye," according to the degree of its inspissation, contains in each pound, from 100 gr. to more than 200 gr. of chloride of sodium, from 1,000 to 2,000 gr. of chloride of calcium, from 200 to 300 gr. chloride of magnesium, 130 to 160 gr. chloride of potassium, some iodide of sodium, chlorides of lithium and aluminum, and about 60 gr. of bromide of sodium.

The justly esteemed Kreuznach system of treatment combines the use of these strong baths with injections, douches, etc., and drinking of the water—in small quantities, if a generally stimulating effect is desired, but in large doses for the absorption of scrofulous and other exudations. I have seen much advantage from it in congestion and chronic inflammation of the uterine system, in hypertrophy and induration of the uterus itself, and of the mammary gland, and in painful irregular menstruation connected with ovarian hyperæmia. It relieves, also, the local congestion and œdema commonly associated with uterine fibroma, and I believe that it even procures, sometimes, the absorption of such growths to some extent (*v.* p. 119).

Chronic eruptions and scrofulous ulcerations also receive benefit from Kreuznach water, and the local use of the "mother-lye" to distorted gouty joints has sometimes given me good results.

Braun compares with Kreuznach the more recent Spa of *Rehme* (Œynhausen), which is situated one hundred and thirty-four feet above the sea, "in a broad and fertile valley watered by the Weser and the Werre," on the railway between Minden and Cologne. The climate is fresh but

mild, and is less changeable than that of many other places; the water is very rich in chloride (240 gr.), and contains also sulphate; it is used principally in the form of warm bath, and differs from the Kreuznach bath mainly in the large amount of carbonic acid it contains. There are also carbonic acid baths (*v.* p. 187), a "wave-bath" in the river under the mill, and a large chamber filled with salt spray for inhalation.

Rehme is suitable for the same kind of cases as are sent to Kreuznach, but in a less advanced stage, and when the subjects are weaker, and too delicate for the stronger methods of the latter Spa. Benefit is said to be obtained from the baths specially in retarded convalescence after fever, fractures, etc., in general debility, anæmia, tabes dorsalis, spinal irritation, and even in spinal meningitis and paralysis. The spray is useful in catarrhal conditions of the respiratory tract.

Kreuth should be mentioned as an example of a high-situated salt Spa, being nearly three thousand feet above the sea, amid Alpine scenery, between Munich and Salzburg. It is sheltered and possesses a pure, rather moist, and particularly *still* atmosphere.

There are here a large "Kurhaus," a "whey-cure," and strong salt baths. The drinking springs contain mainly sulphates, or sulphur. Cases of irritable mucous membranes of scrofulous or tuberculous character are often benefited at this place.

Droitwich is a small salt-manufacturing town, six miles north of Worcester, and fourteen from Malvern. The climate is mild and equable, rather relaxing, and though the place itself is uninviting, there is fine open country in the immediate neighborhood. There is now good accommodation for bathing, and an establishment close to the waters under the direction of Mr. Bainbrigge.

The proportion of saline ingredient is very high—far higher indeed than at any other known spring, there being about 2,500 gr. chloride of sodium, 38 gr. lime sulphate, and 39 gr. soda sulphate in each pound (D. T. Taylor). Used for bathing at about 95° to 112° F., these waters are stimulating and absorbent, and are very serviceable in relieving pain and exudations, and impaired power connected with chronic rheumatic and gouty conditions; also in lumbago and sciatica, in some chronic skin-eruptions, as psoriasis, in glandular scrofulosis, general debility after illness, etc., especially when this is associated with slow circulation and mental depression; serous effusions are also absorbed under their use, and they are said to have proved a powerful stimulant and restorative during the cholera epidemic of 1831. Strong brine baths can be used at a high temperature without the exhaustion and debility that follow an ordinary hot bath.

Woodhall Spa, near Horncastle, in Lincolnshire, has a dry and bracing climate, and is sheltered from north and east winds. The water contains a good proportion of sodium chloride (120 gr. in the pound), 21 gr. of

calcic and other chlorides, and also about ½ gr. of bromide, and ¼ gr. iodide of sodium.

It is used in scrofulosis, and sometimes in chronic gout and rheumatism. Half a pint of it acts as a mild aperient.

There is a saline spring at Harrogate, somewhat similar to one at Kissingen, and called the "Kissingen water." It has more lime and less carbonic acid, and is moderately aperient. Most of the sulphur waters also contain a large proportion of chloride.

CLASS 3.—SULPHUR WATERS.

The sulphur baths of the Pyrenees have been famous from an early period. Most of them are natural baths (Wildbäder), in high mountainous situations, and with a rough climate.

Eaux-bonnes, department Basse-Pyrenées, two thousand three hundred feet above the sea, situated in a narrow sheltered ravine at the foot of the Pic du Gers, about twenty miles from Pau, is rich in grand natural beauties, and has a remarkably pure fresh climate, though it is subject to great changes of temperature during the day.

The waters contain 0.18 cub. in. sulphuretted hydrogen to the pint, with but 2 gr. chloride of sodium, and 2 gr. of other salts, sulphates, and iodides, at a temperature of 90° F.

The dose at first taken is but small, often a tablespoonful, but this is increased gradually to a pint or more, and the good results are said to be so remarkable in tuberculosis and pneumonic consolidation of lung, in asthma, granular pharyngitis, pleuritic effusion, and scrofulous deposits, as well as in chlorosis, amenorrhœa, and atonic dyspepsia, that many physicians "have supposed the cures to be due to some as yet unknown element in the otherwise very poor water." The high situation of the Spa is probably a main agent in its action. The season lasts from June to mid-September, and residence is usually arranged for a month at a time during one or two seasons. Bathing is not much practised, but the patient is recommended to live as much as possible in the open air, and to complete the treatment by a course of sea-bathing at Biarritz.

Eaux-chaudes, situated four miles further on in the same valley, has water containing sulphuret of sodium, sulphate of lime, etc., which are used more for baths than for drinking, in muscular rheumatism, neuralgias, chlorosis, etc.

Ponticosa, in Arragon, a day's journey from Eaux-chaudes, is situated in a valley of the Pyrenees, nearly six thousand feet above the sea. The waters contain much nitrogen and sulphuretted hydrogen, with chlorides and sulphates. They increase the secretions and the appetite, but without exciting the circulation. They relieve the cough of laryngeal

phthisis and bronchial irritation, and are suitable for cases of hæmoptysis, but not for softening tubercle. The best months are July and August.

Cauterets, department Hautes Pyrenées, three thousand two hundred feet above the sea, in a narrow winding valley, has a pure and fresh, but rather variable climate. It contains more than thirty warm saline sulphuretted springs, some of which are highly stimulating, and give rise to feverishness and headache. The *Raillère*, which is famous for the cure of chronic bronchial catarrh, contains in one pound only 0.14 gr. sulphuret of sodium, 0.3 gr. sulphate of soda, 0.3 gr. chloride of sodium, 0.4 gr. silica, nitrogen, and traces of sulphuretted hydrogen, but the water is very warm (102° F.). It is used both internally and by bath, and sometimes gives strikingly good results in early stages of phthisis and strumous deposit, in gastric catarrh, uterine congestions and fluxes, also in chronic rheumatism and skin diseases. Animals, especially horses, with catarrh or abnormal discharges, are also benefited at Cauterets. July, August, and September are the best months.

Barèges, department Hautes Pyrenées, four thousand feet above the sea, with a bracing rough climate, is "the most famous of Pyrenean Spas." The sulphurous stimulating waters are hot (107° F., *Bain de l'Entrée*), warm (98° F.), and tepid (84°). They are limpid, have an oily nauseous taste, characteristic odor, and contain nitrogen and sulphuretted hydrogen, with small quantities of sulphuret, sulphate, and chloride of sodium, etc. On their surface is found a gelatinous pellicle called *barègine* or *glairine*, which is a nitrogenous organic substance, found in most sulphur waters, emollient, and supposed to be efficacious in chronic rheumatism. Sufferers from this complaint, and from sciatica, lumbago, and stiffness of muscles and tendons, visit Barèges in large numbers; it is celebrated also in paralysis, in strumous ulcerations, and especially in bone disease and old gun-shot wounds. The swimming-baths are much used, and the waters are taken internally. They are not suitable for "irritable nervous subjects, nor in heart disease, nor tendency to inflammatory disorder" (Tanner). The season extends from early in June to mid-September. In July and August the crowding is sometimes so great that "invalids must leave their beds soon after midnight for their turns at the baths, and the air in the 'piscines,' from the small space allowed to each bather, is almost intolerable" (H. Weber).

Saint Sauveur, four miles from Barèges, has similar, but milder waters, which are much used by women and children for hysteria, neuralgia, leucorrhœa, and uterine derangements—"pre-eminently the French ladies' Spa" (Braun). The season begins earlier, and lasts later than at Barèges.

Bagnères de Luchon, department Haute Garonne, two thousand feet above the sea, is charmingly placed in a broad valley, close to splendid scenery, enjoys a mild climate, has excellent arrangements for recreation

and abundant sulphurous water, double the strength of those already mentioned. There are about fifty springs, varying in temperature from 63° to 132° F., and containing sulphuret and sulphate, sulphite, and chloride of sodium, other sulphurets, silica, lime, etc. Analysis detects only traces of sulphuretted hydrogen in the waters at the springs, but almost as soon as drawn, they become milky on account of some decomposition with development of this gas, and so much of it escapes from the large bath that the atmosphere above it contains more than 1 per cent. They are used in the same cases as Barèges and Cauterets, etc.

Aix-les-Bains, in Savoy, near Chambéry, seven hundred and ninety feet above the level of the sea, in a sheltered picturesque valley of the Alps, is a celebrated watering-place—the Agnæ Gratinæ of the Romans—greatly resorted to for its sulphurous springs, which are often of much value in chronic rheumatism, gout, neuralgia, and some skin diseases, as well as in paralysis. The temperature of the water varies from 100° to 117° F. They are chiefly employed for baths, the douche-bath being the one most in use. The hot water is made to fall in streams from a height of about 8 to 10 feet upon the patient, who is afterwards thoroughly rubbed, wrapped in blankets, sent home in a sedan-chair, and then put to bed. The climate is mild and relaxing. During the season the place is often unpleasantly crowded.

Aix-la-Chapelle, five hundred and thirty-four feet above the sea, is the principal German sulphur bath. "The amount of sulphuret of sodium in the springs is small, compared with the Pyrenean baths, but the sulphate of soda is rather more, also the sulphuretted hydrogen, and in addition, there are 20 gr. of chloride, and 5 gr. of carbonate of soda, with traces of iodide and bromides. This combination is of much importance for drinking" (Braun). The temperature of the water taken internally is often 130° F.

Warm baths (95° F.), prolonged from half to three-quarters of an hour, are also much used at Aix, with vapor baths, douches, and frictions, and the results of the combined treatment are very satisfactory in rheumatism, gout, chronic eruptive disorders, acne, psoriasis, and abdominal plethora; they are often good, though not so markedly, in paralyses, metallic poisoning, and chronic syphilis, but Braun throws scientific doubt upon the supposed special efficacy of the sulphur in these maladies, and connects the therapeutics more with the temperature and the amount of saline liquid. Mercury is also commonly used in the treatment of syphilis at Aix, not internally, but by inunction of mercurial ointment, from 1 to 1½ dr. being used daily after a warm bath. The value of the baths and water in the treatment of this disorder lies in their (1) increasing the specific action of mercury; (2) preventing salivation and other injurious effects of the drug; (3) keeping the skin in an active state, the glands secreting, and the pores free. The patients are directed to live

well, eat freely of animal food, drink wine, and to be constantly in the open air. Rheumatoid arthritis is also treated with some success at Aix. The season begins early in June, and ends in September. As the treatment is highly stimulating, it is not suitable for apoplectic and hemorrhagic cases.

Weilbach, in the Prussian province of Nassau, in the valley of the Main, on the eastern slope of the Taunus range, has a good sulphurous spring for internal use, the quantity of sulphuretted hydrogen amounting to 0.16 cub. in. Carbonic acid is also present; the amount of salts is small, a few grains only of chlorides and carbonates of soda, magnesia, and lime. "The life here is quiet, and almost solitary." This Spa is specially indicated in some cases of lung disease, catarrhal or tubercular, when hyperæmic enlargement of liver exists, or congestion of the abdominal viscera with hæmorrhoidal tendency, and it will sometimes relieve when Carlsbad and other soda springs cannot be borne. Roth has given reasons for believing that sulphuretted hydrogen, taken in solution into the stomach, acts directly on the blood in the portal vein, forming a sulphuret with the iron of effete blood-corpuscles, and thus hastening their destruction, for the diminution of swelling in the liver under the influence of Weilbach waters is accompanied by a darker and, at length, black coloring of the fæces, in which a large amount of sulphuret of iron is found. This does not come from the water (which contains none of the metal), but either from the food or the blood, and in favor of its being from the latter is the fact that, as the liver decreases in size, an anæmic condition manifests itself in spite of plentiful nutrition. Roth, indeed, insists upon full meat diet during a course of these waters, and a chalybeate course is frequently required afterward. Dr. Braun agrees with these statements, and himself derived much benefit from the waters when suffering from hæmoptysis connected with "hæmorrhoidal enlargement of the liver."

Generally they have rather a constipating effect, and do not increase the intestinal secretions like sulphate of soda waters, though irritation and diarrhœa may be occasionally excited. The refreshing feeling and appetite caused by saline gaseous waters are not felt at the time of drinking these waters, but real *hunger* occurs in the course of the treatment. Besides their medicinal use, already mentioned, in bronchial catarrh, etc., they are valuable in chronic metallic poisoning.

British Sulphur Springs.—*Harrogate*, about thirty miles west of York, is situated part on high level ground, about six hundred feet above the sea, and part in a sheltered valley. It is surrounded by open and pleasant country, and has a pure and bracing though rather moist air; the sandy soil soon dries after rain. The *old sulphur well* and the *strong Montpelier sulphur well* are said to contain 25 cub. in. of sulphuretted hydrogen in a gallon of water, with alkaline and earthy chlorides and sulphides, and traces of bromide and iodide.

They are alterative, stimulant, diuretic, and aperient, and are taken in doses of from one to three tumblerfuls, at intervals before breakfast.

Milder sulphurous springs at the Victoria and Montpelier Gardens are also in use. They contain carbonate of magnesia, and are "antacid, alterative, diuretic, and deobstruent." Both these waters are naturally cold, but are commonly taken warm; they are used also for bathing, the arrangements for which are very good. There are also saline chalybeate and pure chalybeate waters. The social resources of Harrogate and the pleasant climate of summer and autumn (June till October) attract many classes of invalids, but the most suitable cases for treatment by the waters are—dyspepsia with inactivity of liver and bowels, especially when due to high living; constipation, obesity, swelling of joints and glands, chronic skin diseases, gout and rheumatism, syphilis, etc.; cases of incipient phthisis and disordered menstruation in young women are also sent here with advantage, and make use of the warm sulphur baths while taking the chalybeate internally.

Moffat, in the upper part of Annandale, is four hundred feet above the sea, with a good climate and picturesque surroundings. The water, which is cold, contains 2½ cub. in. sulphuretted hydrogen in the pint with 22 gr. of chloride, and 2 gr. of sulphate of soda. It is used internally in much the same cases as the Harrogate sulphur water.

Strathpeffer, in a beautiful part of Ross-shire, has several cold sulphur springs, containing a good proportion of the gas with alkaline and earthy sulphates and 16 gr. of lime salts; these latter render the water somewhat difficult of digestion, and constipating.

At *Llandrindrod*, in Radnorshire, there are sulphur wells of some reputation, described by Macpherson as "mild Harrogate waters." At *Builth* (the next railway station) there is a weak sulphur well, and a saline with 66 gr. of chloride; and at *Llanwityd* there is a weak saline spring with a large proportion (0·62) of sulphuretted hydrogen. The climate at these places is pure and bracing.

The principal sulphur wells in Ireland are at *Lisdoonvarna*, situated in a bare country, about twenty miles from Ennis (county Clare). They are said to contain ½ cub. in. of sulphuretted hydrogen, and are much used, but the accommodation is insufficient. There are also chalybeate springs of good quality.

CLASS 4.—EARTHY MINERAL WATERS.

Wildungen, in the principality of Waldeck, is seven hundred and forty feet above the sea, and, besides a chalybeate, has three earthy springs.

The *Georg-Victorquelle* is a strongly acidulated spring containing 33 cub. in. of free carbonic acid, with 5 gr. of carbonates of lime and magnesia, a little alkaline sulphate, silica, and iron. The *Helenenquelle*, with

34 cub. in. of carbonic acid, has nearly 10 gr. of the earthy salts, with 8 gr. of chloride of sodium and bicarbonate, and a trace of iron. The *Thalquelle*, similar to, but weaker than the Helenenquelle, is more used. It exerts an antacid and diuretic effect, and the two other springs show this in a more marked degree. They are prescribed in vesical catarrh and uric acid concretions in the kidney, and may be either continued alone for a long time, or conjoined with Carlsbad, Vichy, or other more purely alkaline waters.

Leuk (*Leukerbad*, *Loèche-les-Bains*), on the north bank of the Rhone, in the canton Wallis, at the foot of the Gemmi Pass, is four thousand six hundred and seventy feet above the sea. The principal spring, the *Lorenzquelle*, contains 10 gr. of lime sulphate in the pound, with some magnesia and traces of alkalies and iron. It is used internally in doses of one to five tumblerfuls taken at a high temperature (122° F.), and is rather constipating, but diuretic and diaphoretic. Braun attributes more importance to the *warm fluid* than to the ingredients.

But the speciality of Leuk is the mode of bathing. There are four public pools, each three or four feet deep, and accommodating about forty bathers, who, clothed in flannel, amuse themselves with conversation, games, etc., and spend the greater part of the day in the warm mineral water. The time is gradually extended from half an hour to five and even eight hours in the day for about ten days, and then gradually diminished in the same proportion, so that a course is completed in about twenty-five days. The diseases thus treated include gouty and rheumatic exudations, visceral enlargements, scrofulous and other ulcerations, and chronic eruptions, such as psoriasis, eczema, and prurigo. In such cases the lime sulphate acts as a local stimulant, and often causes an erythematous or pustular eruption (poussée), which is the signal for diminishing the baths. The high situation of the Spa enables such stimulating treatment to be better borne than it would be elsewhere.

Weissenburg, in the canton Berne, near Thun, two thousand seven hundred and fifty eight feet above the sea, is situated in a narrow sheltered ravine surrounded by mountains and pine trees. The air is calm, mild, and moist, but the weather variable; the mode of life is simple. The waters are similar to those of Leuk, but with more lime sulphate (17 gr.) and magnesia, much less carbonic acid; temperature, 74.8° F. Excellent results in bronchial catarrh and some forms of phthisis are obtained at Weissenburg, but are to be explained rather by its general conditions than by the composition of the water (Braun). Pleuritic exudations are said to be rapidly absorbed. The waters purge in full doses (six to eight glasses), and sometimes cause dyspepsia at first. Baths are not used in phthisical cases (Rohden).

Lippspringe, a small town near Paderborn, four hundred and forty-one feet above the sea, on a soil of chalk and sand, has a lime spring con-

taining 5 gr. of sulphate and 2 gr. of carbonate, with some sulphate of soda and magnesia, a little iron, some carbonic acid, oxygen, and nitrogen, the latter in comparatively large proportion (1.4 cub. in.); temperature, 70° F. Small doses (12 oz.) constipate, medium quantities regulate the digestion, while 30 to 36 oz. commonly relax the bowels. It is remarkable that under treatment at this place, the appetite and assimilative power of phthisical patients in an advanced stage have improved so much as to lead to an increase in weight of "10 lbs. in four weeks, and 21 lbs. in thirteen weeks." Whatever the explanation, it would seem that the diseased lung-tissue is gradually expectorated during the treatment, with slight fever and moderate suppuration, so that the cavities heal up, and a cure may be completed at higher and drier health-resorts. Possibly the heat of the water and its slight amount of gas, taken fasting, facilitate expectoration and assist in the softening of cheesy deposit and loosening of catarrh (Rohden). Possibly, also, the moisture of the atmosphere assists by keeping in the water of the lungs and skin; the climate is very equable and cool; moist west winds prevail; the noons are cooler, and the mornings and evenings warmer than in other places of the same latitude. Inhalations of nitrogen are also used here.

Inselbad, near Paderborn, is commonly mentioned with Lippspringe as a resort for phthisical subjects, on account of the nitrogen in its medicinal waters. The gas is also inhaled. The weak salt spring (6 gr. chloride, with 2 gr. lime carbonate) is considered valuable in hæmoptysis (Hörling).

CLASS 5.— "*INDIFFERENT THERMÆ*," *or BATHS WITHOUT ACTIVE CHEMICAL INGREDIENTS.*

Buxton, about thirty miles north of Derby, is situated on a lime-stone mountain range, nine hundred feet above the sea. The air is pure and bracing, but subject to sudden variation, and the rainfall is rather large. The season extends from April to November, but June is generally soon enough for a visit, for there are cold, sharp winds in the early spring, as well as in late autumn and winter. The quantity of solids contained in the mineral water is not more than 2 gr. (lime, etc.), in 16 oz. (Lyon Playfair); the gas obtained from it consists of about 99 parts per cent. of nitrogen, 1 of carbonic acid, and a trace of oxygen. Temperature, 82° F.

The water is taken internally, but used mostly for bathing at the natural temperature for about five minutes, and at a raised temperature (93° to 96° F.) for fifteen minutes (Robertson). The plunge, swimming, and douche-baths are very good. A course at Buxton is often beneficial in gout and rheumatism, especially when of a chronic character; also in old sprains and muscular contractions, and in debility, "when the vascu-

lar, nervous, or digestive systems require stimulating." It is unsuitable for hemorrhagic cases. Dr. H. Weber compares Buxton to Schlangenbad.

Bath, Somersetshire, has four warm mineralized springs in the southern part of the town, varying in temperature from 104° to 120° F. The solid contents amount to about 10 gr., in the pound, of alkaline and earthy salts, with a little silica and iron. Nitrogen exists in rather large quantity, and oxygen and carbonic acid in small amount. From a half to two tumblerfuls are taken once or twice daily, with the usual effect of slightly raising temperature, quickening circulation and appetite, and promoting secretion. Sometimes, however, headache, depression, and pyrexia occur.

The accommodation for bathing is very good, and is available the whole year, but the greater number of visitors go between November and April, for the climate is relaxing in the summer; at other times it is mild and equable. Cases of gout and rheumatism of moderate severity, neuralgia and myalgia, contracted joints, etc., some dyspepsias, rheumatic or metallic palsies, leucorrhœa, and *chronic* skin diseases, as psoriasis and eczema, often receive benefit at Bath. I have, however, seen much irritation in several cases of subacute eczema sent to these baths, and there seem to be many nervous irritable subjects with whom they do not agree. It has been called the English Teplitz.

Teplitz, in Bohemia, six hundred and forty-eight feet above the sea, with agreeable surroundings, and a moderately good but changeable climate, is one of the most frequented Spas in Europe, having arrangements for four thousand baths a day. They are generally given very warm, 105° to 109° F., and followed by one to two hours' gentle perspiration in bed. They are highly stimulating and rather predispose to catching cold; a subsequent course of sea-bathing increases their value, which is certainly great in many cases of gout and rheumatism.

Plombières, in the Vosges, in a deep and narrow valley, one thousand three hundred feet above the sea, is "the French Teplitz." The springs are but slightly mineralized, but are very warm (143° F.). The water is taken especially in chronic gastralgia and catarrh of the stomach, and the hot baths are used much in the same manner as at Teplitz, but are commonly more prolonged.

Pfäffers and Ragatz, in the canton St. Gall, have also indifferent thermæ of the same character. The former, in a narrow ravine, two thousand feet above the sea, has warmer baths, but is much less pleasantly situated than the latter place, which lies in a broad bright valley five hundred feet lower down. The waters are taken in four tumblerfuls, and the baths used for half an hour twice daily, in nerve-irritability, neuralgia, hysteria, etc. Season, May to September.

Gastein, a few hours' drive from Salzburg, in a beautiful part of the Tyrol, is one of the highest baths, being three thousand three hundred feet

above the sea-level. "The houses are grouped round the edge of a mountain torrent, which forms a splendid waterfall," and are surrounded by grand and mountainous scenery. The climate is bracing, and rather rough and rainy, but not so variable as at other mountainous resorts. The social tone is monotonous and quieting for excitable subjects. The waters are clear and soft, temperature 96° to 114°, and slightly mineralized—one pound contains only 2½ gr., and more than half of this is sulphate of soda; they are used in warm baths for from ten minutes to an hour. The methods in use at Gastein are milder than at Teplitz, though there are some similar very hot baths for rheumatic exudations and atonic paralysis. The place has a high reputation in such cases, also in hysteria, hypochondriasis, and impotence. If the last-named condition be due to over-excitability of the lumbar cord from sexual excess, it may be relieved by sedative baths; but if from spinal paralysis, it is not likely to be so, and hence very contradictory results have been recorded by different physicians (Braun). Sometimes the cold water system, or that of Rehme or Schlangenbad, will succeed better. It is especially suited for slight cases of spinal congestion or weakness, marked by fatigue on slight exertion and referred especially to the lower spine, by a sense of weight or slight anæsthesia, ataxia, or startings after much walking or standing, sometimes irritability of bladder—such symptoms may be quite removed by a comparatively short course.

Wildbad, in the Wurtemburg Black Forest, one thousand three hundred and thirty feet above the sea, is situated in a beautiful richly wooded but narrow valley, and from its excellent arrangements has become a fashionable bath in spite of a somewhat variable climate. The waters are soothing and refreshing, and are used externally, especially in paralytic cases.

Schlangenbad is close to Weisbaden and to Schwalbach, in a pleasant valley, nine hundred feet above the sea, with a mild, fresh, and equable climate, and is well suited for securing the sedative tonic results of thermal treatment. The arrangements are not on a large scale, but are excellent, the life quiet, and the surrounding forests offer varied and sheltered walks in summer, from June till August. The waters contain only a few grains of soda, lime, and magnesia, at 81° to 86° F. They are used chiefly in the form of warm baths at 87° to 92° in tabes and spinal congestions, and for allaying nervous irritability. Mud-baths are also employed for the same purpose and for improving the skin-condition.

CLASS 6.—CHALYBEATE WATERS.

Protocarbonate of iron, or ferrous carbonate, is contained in a large number of mineral waters, in amount varying from mere traces to several grains in 16 oz. The most used and the most successful contain between 0.3 to 0.9 gr., with free carbonic acid.

It is a truism that minute quantities of iron taken at mineral springs, with the advantages of change, pure air, and often an elevated situation, produce effects as good as, or better than, can be obtained from medicinal doses administered in the ordinary manner. If 0.5 gr. be taken as an average proportion in 16 oz., then only this amount, representing but 0.14 gr. of metallic iron, is taken with each pint; but when once the condition has begun to improve, the iron contained in *food* is better assimilated, so that improvement is continued by natural processes. A few cubic inches of carbonic acid suffice to keep the iron salt in solution (Fresenius), but on exposure to air part of the acid escapes, oxygen is absorbed, and hydrated ferric oxide is deposited. A chalybeate water will keep for some time if not shaken, and it may be heated up to 87° F. without much deposit of iron. A few waters contain sulphate or perchloride.

Of alkaline waters, Gieshübel, Ems, Salzbrunn, Bilin, Luhatschowitz, Apollinaris—of alkaline saline springs, Carlsbad, Marienbad, Tarasp, Franzenbad—and of more markedly saline waters, Kissingen, Wiesbaden, Baden-Baden, Soden, Kreuznach, Rehme, Hall, Adelheidsquelle, and Harrogate, may all be mentioned as slightly chalybeate, and at almost all the great Spas there are some pure stronger chalybeates for use besides the saline; but among those frequented specially for the *iron* waters we may refer to the following:—

The *Kniebis* baths in the Badish Black Forest, twelve hundred to nineteen hundred feet above the sea, with beautiful scenery and quiet bath life.

Bocklet, near Kissingen, six hundred and twenty feet above sea-level, has a mild climate and a rich saline chalybeate water.

Driburg, near Paderborn, six hundred and thirty-three feet elevation, is situated in a pleasant valley, and has a fresh climate.

Königswörth, near Marienbad, two thousand feet above the sea, in a sheltered position on the southern slope of a mountain, has a pure fresh climate recommended for chronic pneumonic and phthisical tendencies. The springs contain from 0.4 to 0.6 gr. of iron bicarbonate, 5 to 6 gr. of salts, and 30 cub. in. carbonic acid.

St. Moritz, in the Upper Engadine, a day's drive from the Coire station, situated in an Alpine valley, rich in vegetation, and five thousand four hundred feet above the sea, has become justly popular, for the air is very refreshing and agreeable even to delicate subjects, especially to those of sluggish circulation and unexcitable nervous system. It is clear and dry, and though dew falls, there is little fog or mist. For a winter residence it is also recommended. The springs contain 0.18 to 0.25 gr. of iron, with a little soda and lime and much carbonic acid (31 to 37 cub. in.), so that the baths are somewhat gaseous: temperature, 39° to 41° F.

Santa Catarina, in Upper Italy, near Bormio, is even higher in situa-

tion (five thousand six hundred), and in waters and surroundings, and scenery, much resembles St. Moritz.

Pyrmont, in the principality of Waldeck, situated in a deep valley four hundred feet above the sea-level, with a healthy, mild climate, and extensive, somewhat old-fashioned arrangements, was formerly the most celebrated of iron Spas. It has one of the stronger compound springs, containing 0.57 of the mineral with lime, magnesia, and free carbonic acid (29 cub. in). There are also salt springs and baths.

Schwalbach, a clean, long-stretching town, on a sloping, sheltered plateau of the Taunus range is nine hundred feet above the sea. It is easily reached from Wiesbaden. It has pure fresh air, excellent arrangements, and strong iron springs, the *Stahlbrunnen* containing 0.64 gr., the *Weinbrunnen* 0.44 gr., the *Paulinenbrunnen* 0.51 gr., with lime, magnesia, soda, and much carbonic acid (40 to 50 cub. in.): temperature, 47° to 50° F.

Spa, in Belgium, one thousand feet above the sea, beautifully placed among the Ardennes forests, at the foot of a lofty wooded mountain, which shelters it on the north, is one of the most frequented iron springs on the Continent at any time from May till September; afterward the climate is apt to be wet and cold. The *Pouhon* spring contains 0.37 gr. of iron, with only 3 gr. of salines and 8 cub. in. carbonic acid. The *Barisart* has more gas and less iron.

At *Harrogate*, the *Muspratt* spring contains perchloride of iron with salines—an unusual and effective combination. The Tewit contains 0.135 gr. of carbonate, with a little saline.

Tunbridge Wells, about thirty miles south of London, three hundred feet above the sea, with healthy climate and beautiful environs, has a pure but weak spring, used formerly much more than it is at present. It contains about ¼ gr. of iron oxide in the pint, but little carbonic acid, so that it is not sparkling. It might be taken with advantage in Apollinaris water.

At Brighton there is a spring, now but little used, which contains sulphate of iron in small amount, and at Malvern, Bournemouth, Sandown, and many other health-resorts there are chalybeates more or less available.

THERAPEUTICAL ACTION.—With regard to the therapeutical use of iron waters, formerly invoked so constantly whenever "strengthening" was desired, we must note that more discrimination is now exercised. Sea-bathing, mountain air, quinine, nux vomica, and other remedies are more used, and iron is ordered more exclusively for true anæmia and chlorosis. Modern medicine, however, recognizes anæmia arising from fever, pneumonia, and most acute disorders quite as distinctly as from hemorrhage (*cf.* Coupland: "Gulstonian Lectures," March, 1881). The more rapidly it is produced, and the more directly from loss of blood, or

of component parts of blood, as in hemorrhage, exudation, or suppuration, the greater the indication for iron in full doses: indeed, officinal preparations are often better in such cases, and chalybeate waters find their use only in later stages.

Their advantages are that they contain a compound (generally a bicarbonate) which is readily digested by the stomach, since it is easily changed into lactate or chloride; that this is well diluted, and so more readily absorbed; and that the free carbonic acid given at the same time is a useful stimulant to the gastro-intestinal membrane. On the other hand, these conditions, under certain circumstances, may be disadvantageous, and a full dose of more concentrated preparations will give better results: for instance, symptoms of *congestion* of the head or chest, under a course of carbonated chalybeate, are referred by many physicians to the carbonic acid rather than to the iron, and in such cases an ordinary pharmaceutical preparation may agree better (Braun).

Simple (true) chlorosis, occurring during the developmental period, seems connected with *direct* loss of iron, which sometimes manifests itself by an increase in the amount passed in the urine (Braun); and it is in this form of anæmia that the administration of iron proves most successful. It is seen among the poorer or the middle classes more frequently than among the higher, in whom chlorosis is often complicated with mental excitement or depression, hysteria, leucorrhœa, etc.

The more indirect the anæmia—when arising, for instance, from impaired general nutrition, with deficiency of albumen and fibrine rather than of blood-cells, or from special derangement of organs or nerves—the slower and the more uncertain is the effect of iron; the anæmia of malnutrition is often better treated by nourishment and hygiene, while the former connected, *e.g.*, with hysteria, may be aggravated by iron internally, but relieved by *indifferent* baths as at Schlangenbad.

Anæmia complicated with or dependent on chronic discharges, such as from caries of bones, diarrhœa, catarrh, etc., is a generally impaired condition of the blood, and should be also treated dietetically, by meat, fat, milk, and with due attention to hygiene. The anæmia of prolonged lactation, which is often accompanied by dyspepsia, requires preliminary medical treatment—weaning the infant being naturally the first indication. In amenorrhœa and other disorders of menstruation, the indication for iron is the degree of anæmia. We should endeavor to put the blood in such a condition that nature can secure from it a healthy result.

Sometimes a salt water (such as Kissingen) and careful hygiene will give better results than iron, while in other cases a compound somewhat purgative iron spring, as at Franzensbad, will be more beneficial. Generally speaking, constipation in these cases requires purgative sulphated or saline waters, while if dyspepsia or diarrhœa be present, they must be combated by appropriate treatment.

Atony of the stomach and intestinal canal is often benefited by a course of iron waters, and the accompanying carbonic acid becomes also valuable in this disorder, which frequently complicates chlorosis and anæmia.

Certain neuroses are also much relieved by chalybeates, but the main indication for their use is the presence of anæmia.

Most iron springs are cold, but are much better borne by chlorotic girls if warmed by the addition of hot water or whey.

ACIDUM ACETICUM—ACETIC ACID, $HC_2H_3O_2$, =60.

Acetic acid occurs in the Pharmacopœia in three grades of strength—(1) The glacial or concentrated acid, which is three times as strong as (2) the ordinary acetic acid, which itself is eight times stronger than (3) the dilute acid. Vinegar is an impure form of the last mentioned.

ACIDUM ACETICUM GLACIALE—GLACIAL ACETIC ACID.

Preparation.—This acid being volatile may be liberated from any acetate by distilling it with a fixed acid, as sulphuric, but its preparation is now left in the hands of the manufacturers.

Characters and Tests.—At the mean temperature of the air, the acid is liquid, but at 34° F. it crystallizes in colorless prismatic crystals, which are not unlike ice, whence the name, glacial. This form is retained up to a temperature of 48° F. The liquid acid has a pungent acetous odor, and is remarkable for the variations in its specific gravity according to its dilution. By the addition of water, the sp. gr. is *raised* from 1.065 till it reaches 1.073 (corresponding to 84 per cent. of anhydrous acid, $C_4H_6O_3$), but any further addition of water permanently lowers it.

ACIDUM ACETICUM—ACETIC ACID.

Preparation.—During the destructive distillation of wood, an impure acid distils over; carbonate of soda is added to the distillate, and an acetate of soda formed, which is purified and distilled with sulphuric acid.

Characters.—A colorless liquid of pungent odor and taste: sp. gr. 1.044. It is volatile and, on evaporation, should leave no residue. Contains 28 per cent. of anhydrous acid.

ACIDUM ACETICUM DILUTUM—DILUTE ACETIC ACID.

Preparation.—By adding 1 part of acetic acid to 7 of distilled water. The sp. gr. is 1.006. Contains 3.6 per cent. of anhydrous acid.

ACETUM—VINEGAR.

Is an impure dilute acetic acid, derived from alcohol. In France it is made from wine, and is stronger than the English vinegar, which is obtained from a fermenting infusion of malt exposed freely to air. The sugar it contains is first changed into alcohol, which by further oxidation (under the influence of a fungus found in the solution) is transformed into acetic acid; thus—

$$C_2H_6O+O_2 \text{ becomes } C_2H_4O_2+H_2O,$$

the acid being derived from the alcohol by the substitution of one atom of oxygen for two of hydrogen.

Characters and Tests.—Vinegar has a sp. gr. of 1.017 to 1.019, is usually brown in color, and has a distinctive odor, due probably to a minute quantity of acetic ether: it contains 4.6 per cent. of anhydrous acetic acid. It is liable to become mouldy if exposed long to the air, and in order to prevent this, a little sulphuric acid is commonly added: $\frac{1}{1000}$ part by weight is allowed by law.

Absorption and Elimination.—The dilute acid is readily absorbed by the stomach, and combines in the blood, to some extent, if not wholly, with soda salts to form acetate of soda; like other salts of vegetable acids this is ultimately eliminated in the urine as a carbonate. The acetate of soda was one of the first salts with which the decomposition was verified by Wöhler (1824).

Physiological Action (External).—Glacial acetic acid is a caustic, and, applied to the ordinary skin, causes redness, pain, and sometimes vesication or even inflammation of the cutis and subjacent tissue. The diluted acids exert a moderately irritant, or simply a cooling astringent effect, according to the degree of dilution, of continuance of application, friction, etc. Mucous membranes are blanched by it.

Physiological Action (Internal).—*Digestive System, etc.*—Dilute acetic acid in moderate doses has a cooling eupeptic action. It diminishes thirst partly by causing a flow of alkaline saliva. In large quantity it lessens secretion of acid gastric juice, and so stops digestion and impairs nutrition.

The stronger acid, taken into the stomach, acts as an irritant poison, and has occasionally caused death; it induces burning sensations in the throat and stomach, and acute abdominal pain with tympanitic distension, tightness across the chest, and much anguish; the buccal mucous membrane is whitened, the tongue becomes dry, cold, and tremulous, nausea, and vomiting occur, with hurried, labored breathing, and quick, small pulse; the pupils are dilated; cold clammy perspirations cover the body; nervous tremor and sometimes convulsions have occurred.

Action on the Blood.—This is very similar to that of sulphuric acid.

Heine (Virchow's *Archiv*, xli., 1867, p. 24) examined the effects of acetic acid brought into direct contact with the blood by injection, and came to the conclusion that the acid decomposes the hæmoglobin, expels oxygen from the corpuscles, coagulates their albuminous substance, together with the hæmatin, causes the passage of this latter into the serum, giving rise to the *lac-color* of the blood. The red corpuscles become finely dotted in the centre, owing to the coagulation of the albumen. The blood remains fluid after only small doses, but is always coagulated by very large ones. After direct injection of the acid into the blood the temperature falls 2° C., though later on, when the destroyed corpuscles seem to act like a poisonous ferment, rigors and muscular tremor occur, with embolism, and septicæmia and consequent rise in temperature. The above-described discoloration of the blood (lac-color) never takes place after the internal administration of the acid, as it does when injected into the veins.

Synergists.—Citric, tartaric, and other vegetable acids.

Antagonists—Incompatibles.—As an antidote in poisoning by caustic alkalies and lime, vinegar is to be recommended, since it is generally near at hand, and the compounds formed by it are not injurious. It is useful also in alcoholic intoxication. Alkalies and their carbonates are chemically incompatible with acetic acid.

Therapeutical Action (External).—The glacial acid is sometimes employed as a *vesicant*, and is used in the acetum cantharidis as a solvent for the active principle of the Spanish fly, and to increase its efficacy.

Nævi—Corns—Warts.—These have been treated successfully with the strong acid, and warts are easily removed by a few applications of it.

Lupus.—In the erythematous form the glacial acid may be applied about twice weekly, with much advantage and without production of scarring.

For *Frost-Bite*, vinegar applied with friction is a good external application.

Cancer.—A somewhat dilute acid (1 part acetic acid in 3 of water) has been used as a local injection into cancerous tissue, and Dr. Broadbent argued that since it dissolved cancer-cells outside the body, and could readily penetrate living tissues (not coagulating albumen), it might lead to local destruction and disintegration of malignant growths when brought into direct contact with them: about 30 min. were injected at a time, and some satisfactory results were reported (*Medical Times*, 1866–67). I have, however, seen harm done by it, and Heine's experiments show some danger in such injections. This method of treatment has not maintained its ground, and is now seldom practised.

Ringworm.—Acetic acid (1 part in 3) has been applied in this disorder, and with good results, but other remedies are more commonly used.

Psoriasis.—Acetic acid used locally promotes separation of the thick

scales of psoriasis, and stimulates healthy action, just as a blister will sometimes do, but it causes much pain if the skin is fissured.

Hemorrhage.—Syringing with vinegar is frequently used as an astringent and styptic remedy for bleeding from the nose, and sponging with it for parenchymatous hemorrhage; in metrorrhagia it may be used by vaginal injection, or tampons may be soaked in it. These, however, irritate and become unpleasant in four to six hours.

Nocturnal Sweating.—The night-sweats which are so profuse and exhausting in the later stages of phthisis and in some conditions of debility, are often controlled by sponging the body with warm vinegar night and morning.

Spermatorrhœa.—Compresses soaked with vinegar and applied to the perineum at bed-time often cure this affection. Should soreness be produced, treatment must be omitted for a time.

Spinal Weakness.—In cases of aching and debility referred to the lower spine, and dependent probably on impaired power of the erector spinæ, I have seen much advantage from sponging the back with equal parts of spirit of wine and dilute acetic acid.

Therapeutical Action (Internal).—*Scarlet Fever.*—Dilute acetic acid is used by some practitioners from the commencement of this fever in all cases. Freely diluted, it certainly makes a grateful refrigerant drink. Where the eruption is more or less suppressed, a teaspoonful of vinegar given in sweetened water every two to four hours for a few doses, is said to cause diaphoresis, and to assist in bringing out the rash: however this may be, sponging the body with hot vinegar and water twice or thrice daily is often useful.

Dr. J. Dougall specially recommends the aromatic glacial acetic acid impregnated with neroli, rosemary, etc.—1 dr. to the oz. of water is used for sponging, and some is volatilized in the sick room (*British Medical Journal*, ii., 1879).

Diarrhœa.—When this occurs in the course of phthisis, or hectic fever, it may sometimes be controlled by the internal administration of vinegar.

Obesity.—When vinegar is taken continuously for five to six weeks, it causes emaciation, and in cases of obesity was formerly used with the object of taking down superfluous fat. A wineglassful was given each morning, fasting, and again at bedtime, but serious consequences, such as phthisis, etc., having occasionally followed this treatment, it has fallen into disuse.

Preparations and Dose.—*Acidum aceticum glaciale:* not given internally. *Acidum aceticum:* used externally as a rubefacient, vesicant, and escharotic. *Acidum aceticum dilutum:* dose, 1 to 2 fl. dr., or more, well diluted. *Oxymel:* dose, 1 to 2 fl. dr. *Acetum* (vinegar): dose, 1 to 2 fl. dr.

[Preparations, U. S. P.—*Acidum aceticum*, sp. gravity 1.047. *Acidum aceticum dilutum:* acetic acid 1 pint, distilled water seven pints; *Acetum*].

Adulterations.—Sulphuric acid and metallic impurities taken up from metal vessels in which it has been kept.

ACIDUM CARBONICUM—CARBONIC ACID, CO_2,=44

(not officinal).

This gas occurs in the atmosphere in the proportion of 2 to 6 parts in 10,000; the air contained in the interstices of arable land has more, and in some grottoes and natural hollows, communicating probably with ancient volcanoes, carbonic acid accumulates, so as to exert toxic effects. This is the case in the well-known Grotto del Cane at Naples, the Upas valley of Java, and in many parts of Auvergne and Vivarais ("estouffis"). The gas is contained also in all water in varying quantity, certain sparkling waters having a proportion of more than half their volume. It occurs in all the liquids of the organism, principally in the blood, but also, in less quantity, in the urine: in the former, it exists combined with alkali, chiefly soda, and also in a free state; in the latter Morin found a proportion of 20 cub. cent. to the litre: this was increased under administration of carbonated water, also after walking exercise: it was greatly diminished by free drinking of ordinary water. It originates in the chemical phenomena of combustion and nutrition which are constantly taking place in the tissues, and it readily passes by osmosis through the animal membranes.

Preparation.—By treating any carbonate—usually carbonate of lime—with dilute hydrochloric acid: the resulting gas is passed into water under pressure, and a solution is thus obtained.

Characters.—A colorless inodorous gas of slightly sharp taste. It is soluble in its own volume of pure water at ordinary temperature and pressure—much more soluble under increased pressure and lowered temperature of the water. The solution gives an acid reaction, and is "sparkling" from rapid escape of gas. Carbonic acid is much more soluble in water containing *phosphates* than it is in pure water, and conversely, water containing the gas can dissolve and retain in solution, *carbonates* and *phosphates* of magnesia, lime, iron, etc., which pure water cannot. The sp. gr. of the gas is 1.526 (atmospheric air taken as 1). It is twenty-two times heavier than hydrogen.

Absorption and Elimination.—Carbonic acid is easily absorbed by denuded surfaces, and by mucous and serous membranes. That it may

be absorbed also through the unbroken skin is apparent from the systemic effects produced not only by carbonic acid baths in general, but by keeping separate limbs in an atmosphere of the gas while the respiratory organs are protected from it (Collard de Martigny). If taken in solution into the stomach, it is said to be absorbed, if the viscus be *empty*—while if it be *full*, the gas is rejected by eructation and per anum as flatus (Lehmann). Up to a certain amount, it may be absorbed through the lungs by the blood. In any normal condition, the blood is never *saturated* with the gas, but is always ready to receive more as it is freshly formed in the tissues. It circulates partly dissolved by the serum and partly combined with alkaline salts. It is eliminated almost entirely by the lungs and the skin, but in small proportion by the kidneys; also by the large bowel.

Physiological Action (External).—When carbonic acid gas, undiluted, is brought into contact with the skin, it causes some prickling and sense of warmth, with or without redness; this is said to be most marked about the perineum and scrotum—the latter contracts under its influence. To this effect succeeds a certain degree of anæsthesia (Rotureau) or analgesia, which, however, is not complete enough for operative purposes (Demarquay). In contact with mucous surfaces, or the exposed cutis vera, the effects are more marked, and more quickly produced. The oculo-nasal membrane is especially sensitive to a current of the gas, while the uterine membrane, and even wounded surfaces show the anæsthetic effect without much previous stimulation.

Physiological Action (Internal).—*Digestive System.*—When taken into the stomach, as it usually is, in aqueous solution, carbonic acid is refreshing and thirst-quenching. It somewhat increases the gastro-intestinal secretions, and excites their peristaltic action, but diminishes the sensibility of the mucous membrane. A moderate quantity improves appetite, but an over-dose lessens it. No such serious symptoms follow, however, as after inhalation of the gas by the lungs.

Respiratory System.—The gas is markedly more poisonous when inhaled than when taken in any other way. It hinders exhalation of the carbonic acid normally existing in the blood, and is itself absorbed in small quantity, thus inducing dyspnœa; a proportion of 10 per cent in the air is irrespirable and fatal. The undiluted gas first excites irritation and sometimes spasmodic contraction of the glottis with consequent asphyxia (Wareing); in any case, and independently of such spasm, it soon arrests respiration. It has been thought that the gas is itself inert, and induces death only by preventing the due interchange of oxygen and carbonic acid in the lungs (Bichat, Regnault, etc.), but recent observations suggest that it is actively poisonous, since young mammals die by cardiac arrest after two or three minutes in an atmosphere charged with it, while they live fifteen to twenty minutes in nitrogen or hydrogen (Paul Bert,

Rabuteau), and the heart continues to beat in the latter case after respiration has ceased. The experiments of Collard de Martigny, Orfila, van Hasselt, and others, point to the same conclusion.

Circulatory System.—The effect of respired carbonic acid in preventing oxygenation of blood is quickly shown by the appearance of more or less cyanosis, with slow, labored pulse, and ultimate arrest of heart-action. It does not, however, intimately combine with, and fix itself upon, the hæmoglobin, since this remains red and unreduced in an atmosphere even highly charged with carbonic acid, provided that a normal amount of oxygen is present also; while in animals dying deprived of oxygen, the blood is found black, hæmoglobin being completely reduced. The effects of the internal administration of the gas, or even its careful injection into the larger venous trunks, differ from those produced by its inhalation, and are such as slight stimulation of the heart-action, quickening of respiration, and increase of the peripheral circulation, with a slight prickling of skin and brief sense of exhilaration; this is often experienced from sparkling beer, wine, and even waters. Husemann remarks that experiments with "direct injection" of carbonic acid into the blood (Nysten, Demarquay) have not led to great results, on account of the smallness of the amount that can be injected without death occurring from the entrance of air into veins. Even small quantities thus injected cause muscular weakness, a symptom which only appears *late* in the inhalation of dilute carbonic acid gas.

Nervo-Muscular System.—The most marked effects of carbonic acid poisoning (from breathing the gas) are exerted upon the nervous system. An amount of 3 per 1,000 in the atmosphere of a room will cause throbbing headache, with fulness and tightness across the temples, and giddiness: more of the gas may induce fainting, muscular weakness, somnolence, or insensibility, coma, or convulsion.

Brown-Séquard taught that carbonic acid was a muscular excitant, because of the uterine contractions observed after injecting into the vagina, the excitement induced by arterial injections of blood charged with carbonic acid, and the convulsions said to be caused by directing the injections toward the head. Cyon further taught that the cardiac arrest caused by this gas was due to excitement of the vagus, but more modern observations lead us to regard the gas rather as a sedative. I have already mentioned the local anæsthesia it can produce, and Leven always found in his experiments anæsthesia with slowing of respiration and circulation, and finally cardiac arrest—no convulsion. I should say with Rabuteau that in therapeutical doses it modifies sensibility, while in toxic quantity it abolishes at once the functions of nerve and muscle. On the organs of special sense, anæsthetic effects are preceded not only by prickling and warmth, but also by muscæ volitantes, tinnitus, and other phenomena connected with congestion. Herpin found that

the gas, when diluted with 80 to 90 per cent. air, produced gradual anæsthesia without suffocation or pain.

Nutrition—Excretion.—The inhalation of carbonic acid modifies the processes of nutrition in a manner not yet understood: sugar has been found in the blood and liver of animals poisoned by it. More *diuresis* is caused by *carbonated*, than by ordinary water.

Synergists.—Alcohol, ether, and other hydro-carbons cause intoxication and produce anæsthesia somewhat similar in character.

Antagonists.—Oxygen and stimulants of the peripheral circulation.

Therapeutical Action (External).—*Wounds, etc.*—Demarquay and Leconte found that atonic and gangrenous ulcers and diphtheritic wounds recovered under applications of carbonic acid gas when they had not yielded to other remedies. The cicatrization of wounds was also favored by it, and when injected into the cellular tissue in cases of tenotomy, repair of tendons was said to be hastened by it, while by oxygen it was retarded. Good results in the same class of cases have been reported from Rehme, Nauheim, and other Spas where the gas is employed therapeutically (*v.* p. 167).

Vesical Catarrh, etc.—The pain, the muco-purulent discharge, and the irritability of bladder connected with this malady, may certainly be relieved by local injections of carbonic acid gas—a method of treatment not, perhaps, so often used as it deserves to be. Dr. Johns, Sir James Simpson, Dr. Skinner, and others have reported much improvement in many severe and chronic cases (*British Medical Journal*, 1858; *Medical Times*, 1858–59). The gas is disengaged from a carbonate mixed with tartaric acid, and conveyed through a catheter, the bladder being previously washed out if possible. It is desirable to avoid over-distension of the viscus, either by using only a measured quantity (Skinner), or employing a double catheter (Johns). If too much be injected, there may be some burning pain, and afterward drowsiness and sense of exhaustion, but these symptoms are temporary, and are, in most cases, not felt at all, while relief follows very quickly and lasts for a long time, suggesting that the gas is retained in the bladder for several hours before being absorbed: its use is commonly though not always followed by excretion of urine containing much mucus and oxalates.

The gas may be employed in almost all forms of irritability of the bladder, unless acute inflammation be present—if irritation be severe, it may be diluted with air.

Gout—Paralysis.—At Kissingen, baths containing carbonic acid gas are much used for these maladies. Dr. Parkin wrote strongly upon the value of carbonic acid in gout, but administered it in the complex form of a strong alkaline effervescent draught (*Lancet*, 1843).

Pelvic and Uterine Pain.—In many painful affections of the pelvic viscera, whether neuralgic, sympathetic, or even arising from organic dis-

ease, injection of carbonic acid into the vagina acts as an anæsthetic and sedative; but as it sometimes increases irritation for a time, it is not suited for cases with acute congestion. Dewees, de Rossi (1834–35), and other physicians of still earlier date, used the gas with advantage, and Sir James Simpson records ample and favorable experience with it in dysmenorrhœa, etc. It gives relief even to the pain of cancer, but seems to have sometimes caused giddiness, headache, and weakness (Bernard: *Medical Times*, i., 1858, p. 380). The warm baths at Driburg (Westphalia), which are highly charged with carbonic acid, are said to be useful in cases of anæmic amenorrhœa and leucorrhœa, and to exert a favorable influence upon utero-gestation, so that healthier children are born after their use. They have been described as "champagne baths," and exert a stimulating effect upon the whole surface, especially upon the genitals; they also induce a free secretion of urine. They relieve partial or hysterical paralysis connected with pelvic irritation, but are contra-indicated in acute congestion and in epilepsy.

At the "sool-sprudel" of Kissingen, especially when heated or when agitated by jet or wave, so large an amount of gas passes into the air as to cause sometimes giddiness, dyspnœa, etc. At Rehme the baths are used "still" with better result, especially in certain forms of paralysis and spinal irritation. At this place, also, gas-baths are given, but Dr. Braun does not attach much value to them unless in cases of atonic ulceration, and in irregular menstruation from atony of uterus.

Scanzoni injected carbonic acid gas into the vagina or uterus to induce premature labor, and with successful results (*British and Foreign Review*, ii., 1856), but the method is not desirable on account of some risk of the gas entering a large vein. Dr. Tyler Smith has pointed out that abortion occurs where pregnant women are exposed to the poisonous influence of the gas, but this may be secondary to the asphyxia produced.

Phthisis.—Inhalations of carbonic acid are indicated in certain irritative forms of pulmonary phthisis, as likely to diminish active erethism and slow the progress of destruction (Withering, Beddoes, etc.). The air of stables is said to be beneficial partly for this reason.

Pharyngitis—Granular Angina.—Chronic cases of these maladies and of laryngitis are treated at Ems by inhalation of the gas, and at Vichy by the carbonic acid douche.

Chronic Bronchitis—Asthma.—Simpson states that he has often seen benefit from inhalations containing 5 to 10 per cent. of carbonic acid in these maladies, and in chronic cough. Such inhalations are much better tolerated than is commonly thought (Skinner), and they are practised at St. Moritz, at Ems, and elsewhere, but Dr. C. T. Williams speaks of danger arising from them, on account of difficulty in regulating the dose (*Lancet* ii., 1873, p. 516). The relief given in asthmatic attacks by the fumes of nitre paper has been attributed to the carbonic acid contained in them,

and it is a matter of clinical experience that asthmatic patients frequently breathe better in a crowded part of a town—where the amount of this gas is greater—than they do in the pure air of the country.

Vomiting—Dyspepsia.—When the gastric mucous membrane is morbidly sensitive and irritable, carbonic acid gas dissolved in water is an excellent sedative, and in uncomplicated cases is sufficient to relieve vomiting. It is commonly given in combination with an alkali, as in the ordinary effervescent mixture, or in the waters of Homburg, Carlsbad, Vichy, etc., but water charged with the gas *only*, often answers exceedingly well, and has sometimes cured intense gastric irritation (chronic in character with great nerve-depression) after the failure of treatment at celebrated Spas.

There are other virtues attributed to carbonic acid, which are not so well ascertained. Thus, Dr. Parkin and Dr. Ritson argued that the freedom of many ports from *cholera* was traceable to the increased amount of carbonic acid in the atmosphere of their coal works and wharves! (*Lancet*, ii., 1848).

ACIDUM CITRICUM—CITRIC ACID, $H_3C_6H_5O_7$, H_2O=200.

This acid occurs in many plants and acidulous fruits, especially in those belonging to Aurantiaceæ or orange family, and is commonly obtained from lemon or lime-juice (*cf.* vol. i., p. 96).

Preparation.—The lemon-juice is first boiled, in order to coagulate the albuminous substances, and then saturated, while hot, with chalk, so that *citrate* of calcium is formed; this is washed with hot water (it would dissolve in cold), and then treated with sulphuric acid, which forms *sulphate* of calcium (to be removed by filtration), and the solution concentrated at a moderate temperature, to allow citric acid to crystallize out. (1) $2H_3C_6H_5O_7+3CaCO_3=Ca_3{}_2C_6H_5O_7+3H_2O+3CO_2$. (2) $Ca_3{}_2C_6H_5O_7+3H_2SO_4=3CaSO_4+2H_3C_6H_5O_7$.

Good lemon-juice yields from 2½ to 10 per cent. of citric acid, the quantity varying because it decreases in proportion to the time that the lemons are kept, and it may quite disappear, separating into glucose, carbonic anhydride, and some acetic acid.

Characters.—Occurs in colorless crystals of which the right rhombic prism is the primary form; they are permanent in dry, but become moist in a damp atmosphere; sp. gr. 1.6; taste strongly acid, and almost caustic, but in weak solutions only agreeably acid and refreshing; very soluble in water and in glycerin, less so in spirit, and not at all in ether. Seventeen grains of citric acid (equivalent to about ½ oz. lemon-juice) saturate 13 of magnesian carbonate, 15 of the ammoniacal, 20 of the soda, 25 of the potash

salt; somewhat less than these quantities are commonly used. A small proportion of citric acid prevents some chemical decompositions, *e.g.*, in the syrupus ferri iodidi.

Absorption and Elimination.—Citric acid is readily absorbed by the stomach and intestines, and is excreted in part by the kidneys in the urine in combination with bases. The greater part is oxidized in the system, forming carbonic acid and water. Buchheim and Pietrowski found none in the urine after 30 to 60-gramme doses. According to Bence Jones and Eylandt, the acidity of urine is increased by citric, as it is by tartaric acid, and a deposit of free uric acid may be induced by it.

Physiological Action.—Concentrated solutions do not irritate the skin, hence Mitscherlich and others conclude citric to be *less irritant* than tartaric acid, but abraded surfaces and mucous membranes become irritated by it; and although it is not known to have caused death in man, Husemann considers it, from its effects on animals, to be *more poisonous* than tartaric acid. Eight to fifteen grammes destroy large rabbits within one hour, with cramp, opisthotonos, dyspnœa, weakened heart-action, and general prostration. Bobrik observed tremor and cramp, difficulty of breathing, slowing of pulse, and lowering of temperature (in rabbits). On dissection the blood was found fluid, and the gastro-intestinal mucous membrane inflamed and ecchymosed.

Synergists.—Tartaric and other vegetable acids.

Incompatibles.—Alkaline carbonates, acetates, and sulphurets; tartrate of potash.

Therapeutical Action (External).—*Cancer, etc.*—A solution of citric acid—60 to 90 gr. in 8 oz. of water—will sometimes markedly relieve the pain of cancerous ulceration. I have verified this fact in cancer of the tongue, of the breast, and of other parts, without being able to explain it. It is not generally known, but has been several times recorded, *e.g.*, by Brandini, by Denny (*Lancet*, i., 1866), and Barclay (*British Medical Journal*, i., 1866). Chronic cases of psoriasis and eczema, especially in gouty subjects, are relieved by the daily use of slices of fresh lemon.

Pruritus.—A hot lotion containing citric acid is often serviceable in relieving itching.

Therapeutical Action (Internal).—*Irritability of Stomach.*—In cases of dyspepsia, marked especially by local discomfort, much thirst, and tendency to nausea or sickness, effervescing alkaline citrates are often both grateful and remedial. Citric acid, or its compounds, are good refrigerants, and allay thirst in cases of fever.

Rheumatism.—To the observations already made on this subject (vol. i., p. 96), I have to add that citric acid is specially indicated in those perhaps exceptional cases of rheumatism when the urine is alkaline, either from some peculiarity in the attack or from too prolonged use of

alkali, and when depression is a marked symptom. In such a condition, occurring together with bronchitis and valvular disease in a gouty subject, I have seen lemon-juice given with some alcohol relieve after failure of alkalies, iodides, etc.

In *Scorbutic Dysentery*, lemon-juice was commended by Sir William Ferguson (*Edinburgh Medical Journal*, October, 1837), and for *ammoniacal urine* by Dr. Bence Jones. I have used it in the latter condition, and found it serviceable.

Preparations and Dose.—*Acidum citricum:* dose, 10 to 30 gr., diluted and sweetened.

Adulteration.—Sometimes tartaric or sulphuric acid.

ACIDUM HYDROCHLORICUM—HYDROCHLORIC ACID, HCl, = 36.5,

Is found in the animal kingdom, in the gastric juice of mammals and fishes; in the vegetable kingdom (Isatis tinctoria); in the mineral kingdom combined with metals, earths, and alkalies (sodium chloride, etc.), and in the springs of volcanic regions. The hydrochloric or muriatic acid of the Pharmacopœia is a solution of hydrochloric acid gas in water, to the extent of nearly 32 per cent. by weight.

Preparation.—Being a volatile acid, it can be prepared from any chloride by distillation with the less volatile sulphuric acid—common salt is usually employed, and hence the acid has been termed "spirit of salt," and "marine acid." When salt is mixed with dilute sulphuric acid, sulphate of sodium is formed, and free hydrochloric acid distils over into a receiver containing water, in which it is very soluble.

$$NaCl + H_2SO_4 = NaHSO_4 + HCl.$$

Characters and Tests.—The pure acid is colorless, but the commercial acid yellowish, owing to the presence of some organic matter, as cork, or of ferric chloride, from the iron stills in which it is prepared. It has a very sour taste and a suffocating odor, giving off white fumes when exposed to the air, from escape of the acid gas, and its union with the moisture of the atmosphere. A rod dipped in liquor ammoniæ and held over a bottle of the acid forms dense white fumes of sal ammoniac; nitrate of silver produces a curdy white precipitate of chloride of silver, insoluble in nitric acid, soluble in ammonia, and becoming dark on exposure to light. The sp. gr. of the acid varies with its strength, the strongest having a density of 1.21. The application of heat should dissipate it without residue, implying the absence of lead and solid impurities. It may contain sulphurous acid, which would be detected by action on lead-paper.

Absorption and Elimination.—The mineral acids in moderately strong solution may be absorbed through the skin, as proved, for instance, by the physiological effects produced by the nitro-muriatic bath. Dilute hydrochloric acid, taken internally, is absorbed by the stomach, probably unchanged, but any that passes into the intestines would have time to combine in part with soda, and form chloride of sodium before entering the capillaries. It has been said that any acid introduced as such into the blood becomes so closely combined with the albumen as to reach the emunctories before being wholly combined with alkali, but if so, the acid is not traceable by test paper (F. Walter: "Die Wirkung der Saüren, etc.," *Archiv. für Exper. Pathol.*, April, 1877). According to this careful observer an acid reaction of the blood is incompatible with life. Elimination is effected mainly by the urine, the quantity and the acidity of this excretion being usually increased.

Physiological Action (External).—Strong hydrochloric, like other mineral acids, acts with energy on animal tissue, abstracting water, and combining with potash, soda, and lime bases: it does not penetrate so deeply as sulphuric or nitric acid, but produces a white stain, and this part afterward sloughs. On the digestive tract, strong doses have a similar action, and excite gastro-enteritis. Fermentation of any kind is arrested by this acid. Dr. John Dougall considers it, when diluted with twenty parts of water, "the cheapest, most easily used, and most effective non-aerial disinfectant," especially for typhoid excreta and the bed and body-clothes of persons with infectious disease (*British Medical Journal*, ii., 1879).

Physiological Action (Internal).—*Digestive System.*—Administered in moderate dose and dilute solution, hydrochloric acid has two main effects—(1), it augments the acidity of the gastric juice, and (2), after absorption, it gives rise to extra-formation of chloride of sodium. It is first eupeptic, and then assists hæmatosis; it also aids the solution of useful substances which would be otherwise inert, such as phosphate and carbonate of lime, metallic iron, oxides, etc. (Rabuteau).

The augmented acidity of the gastric juice, as a rule and within certain limits, improves the digestive power and increases formation of peptones; it is accompanied by greater secretion of saliva, and a sense of warmth at the stomach, but if carried to excess causes irritation. A great part of the interest connected with the study of this acid depends upon the question whether it really forms an integral part of the normal secretion of the gastric glands, and there is certainly a large amount of evidence in the affirmative. Besides the older observations of Prout ("Philosophical Transactions," 1824), of Lassaigne (*Journal de Chimie*, t. x.), and others, we have the more recent analyses of Schmidt ("Die Verdauungssäfte," 1852), and of Gautier ("Chimie Appliquée," 1874), who even calculate the proportion of free hydrochloric acid as 3.05 per 1,000. It

is not denied that lactic, acetic, and butyric acids may also be found in the gastric juice, as described by Cl. Bernard, Lehmann, and other eminent authorities, but it is almost certain that they result from chemical changes during the digestion of foreign substances. Enderlin, examining the quite fresh gastric secretion of an executed criminal, could find no trace of lactic acid, nor could any *organic* acid act on fluoride of calcium as gastric juice does (Melsens). Further, Rabuteau claims to have demonstrated by an original process the existence of hydrochloric acid in the secretion of fishes (*Comptes Rendus*, 1873) and of dogs ("Eléments de Thérapeutiques, 1875, p. 429). After a fast of twenty-four hours he gave to two animals some bits of tendon, and about an hour afterward divided their medulla. The very acid gastric juice was collected, filtered, saturated with pure quinine, evaporated, and divided into two portions. One part was exhausted by benzine, which can dissolve hydrochlorate and lactate of quinine (though not alkaline chlorides), and on evaporating the benzine, hydrochlorate of quinine was easily recognized. The other part was treated by amylic alcohol, which was then evaporated, and the residue treated by chloroform, which took up a salt proved to be solely hydrochlorate of quinine without trace of lactate. He estimated the quantity of free acid at 2.5 per 1,000—not very different from the results of Schmidt, and we may fairly presume that the acid is derived from the chloride of sodium circulating in the blood. Lactate of soda is not likely to circulate, inasmuch as it would, very soon after absorption, be changed into bicarbonate. "A free acid always exists in gastric juice, which is usually hydrochloric, rarely lactic acid alone, not unfrequently a mixture of both acids" (McKendrick's "Physiology," 1878).

If, then, hydrochloric acid be the normal acid of the gastric juice, it would seem to be the one most easily assimilated by the stomach, and should be preferred, as a rule, when acid is indicated. It is scarcely necessary to state that if administered undiluted this acid causes irritant poisoning with symptoms similar to those described fully under sulphuric acid.

Circulatory System.—As the blood and lymph, and almost all the secretions of the body have an alkaline reaction, it becomes interesting and important to inquire what effect is produced upon such alkalinity by the administration of acids. Some observers, as Eylandt, Wilde, and Gaethgens have concluded that any altered relation of acids and bases within the body occurs, if at all, within very narrow limits.[1] Hoffmann held that an excess of free acid can pass through the blood to the urine, but this is probably incorrect. Miguel, after giving sulphuric acid, found the *alkaline salts* of the urine increased in amount—implying that the acid

[1] Souligoux attaches much importance to it, as altering galvanic reactions within the system.

combined with alkali in the blood, and thus removed from that fluid for excretion an unusual proportion of such alkali. Salkowski arrived at a similar conclusion, and Lassar asserted, from analyses of blood, that its alkalinity was much lowered under the use of acids. But the estimation of urinary ingredients does not give a satisfactory answer to the question, and alkalimetry, as applied to the blood, is exceedingly difficult, hence another and an ingenious method of analysis has been adopted by F. Walter (op. cit., April, 1875). Starting from the highly probable supposition that the carbonic acid contained in the blood must be almost wholly in combination with alkalies, and that its amount must therefore be proportional to, and be an index of, the amount of alkali contained in that liquid, he analyzed the gas-contents of blood withdrawn from animals under acid-treatment, as compared with that of animals in a normal condition. Most of his experiments were made with hydrochloric acid, because it required less water for dilution than other acids. From 1 to 3 grammes of acid were given diluted, in three doses, by the stomach tube, in the course of twenty to forty hours. The blood was drawn from veins after decided symptoms of acid-poisoning had set in, and when compared with normal blood it showed a remarkable *lessening* of the carbonic acid, and (by inference) of combined alkalies. This was especially the case in rabbits (herbivora). While normal rabbit-blood showed an average percentage of 25 volumes CO_2, that drawn after 1·22 grammes of acid gave 16, and after 2·44 grammes of acid, only 3 volumes of the gas; this blood was dark, and coagulated with difficulty, but was decidedly, though weakly, alkaline in reaction. In dogs (carnivora) the difference was not so great, but a diminution of about 10 per cent. in the amount of CO_2 occurred under the influence of hydrochloric acid. This curious difference between the effects of the acid on the two classes of animals was first pointed out by Salkowski, and it was found that dogs have a certain immunity as to the general symptoms of acid-poisoning, so that they can take much larger doses than the herbivora without ill results. (This has been accounted for by the increased formation of ammonia compounds in the latter class of animals under the influence of the acid, causing its neutralization, to some extent). The experiments of Walter prove, however, that it is possible, by means of the internal administration of acids, to withdraw alkalies from the vital fluids, and this to such an extent as even to cause death from their deprivation.

With regard to the influence of hydrochloric acid on the general circulation, it was noticed by early observers—Boerhaave and others—that even moderate doses accelerate the pulse and cause flushing of the face; and full doses produce some excitement of brain-function, so that the symptoms have been compared to those caused by alcohol (Deutsch). Bobrick took 18 min. diluted with 5 oz. of water, and within half an hour noted an increase of pulse by six beats. This continued for an hour, but

was succeeded by a fall of four beats below the normal frequency. He noticed excitement of similar character after internal and external applications of the acid to frogs, and concluded that it was produced through the nervous system, for it did not appear after destruction of the nerve-centres.

Respiratory System—Toxic Action.—F. Walter found that in different animals of the same species, the action of the acid was different; from 7 to 8 grammes of hydrochloric acid per kilogramme of body-weight might be given to a rabbit in one day without necessarily serious result, but if the proportion of 9 grammes in the same period were exceeded, death certainly followed within a few hours. The first symptom of poisoning was an increase of frequency in respiration; then the separate breath-movements became deeper and more laborious, with violent heaving of the thorax; the heart beat so quickly that the pulse could not be counted; the animal lost power of moving, and lay quiet on the side for a quarter of an hour before death. The respiration then lost its dyspnœal character, and grew superficial and weaker as collapse set in, and the heart-action ceased a few moments after the breathing (loc. cit. p. 157). Post-mortem inspection revealed no sufficient change in the organism to account for these symptoms; sometimes, it is true, erosion of the gastric membrane occurred, but the course of the poisoning was not altered in such cases, and therefore it could not be dependent on such erosion: a different concentration of solution, whether 4 or 8 per cent., made no difference in the symptoms; the blood was only so far altered that it coagulated more slowly than usual. It was not found acid in reaction. Hence apparently neutralization of alkali, or withdrawal of some portion of alkali from the blood and tissues, was the cause of death; and this hypothesis was remarkably confirmed by the results of injection of an alkali into the blood-current after full and toxic doses of acid had been given by the stomach. A rabbit that had received more than 6 grammes of hydrochloric acid in three days—three times as much as would kill it—together with 0·2 gramme carbonate of soda injected under the skin with each dose, recovered without loss of appetite or any symptom of poisoning. Another animal received more than 2 grammes of acid, and just when the symptoms indicated the near approach of death 0·5 gramme of soda carbonate was injected into the jugular vein; within ten minutes the strong thoracic movements subsided, the heart-action grew slower and stronger, the animal sat up and began to eat, and in an hour's time seemed quite restored. This direct antidotal action of injected alkali is very striking.

It would seem that the result of diminished alkali in the blood is first a stimulation and then a palsy of the respiratory centre, through which death may be induced. The dyspnœa is not connected with altered heart-action, and the paralysis of respiration must be distinguished from that of asphyxia, for the oxygen contained in the blood remains unchanged.

Synergists.—As refrigerant, tonic, and astringent, the other acids; as tonic and digestive, bitters, and also pepsine and possibly pancreatine.

Incompatibles.—Alkalies and bases, salts of silver especially. To neutralize irritant poisonous doses of acid, the alkali should be given in mucilaginous or albuminous liquids.

Therapeutical Action (External).—*Stomatitis, etc.*—In inflammation, with patches of ulceration about the mucous membrane of the mouth and gums, hydrochloric acid, diluted with an equal part of glycerin, and applied to the sloughing spots will induce healthy action. In mercurial stomatitis, and in the aphthous conditions that occur in children, or during advanced disease, lotions containing 1 part of acid in 10 of rose-water, either alone or with chlorate of potash and glycerin, are very serviceable. The acid is also valuable given *internally* in such cases. To avoid possible injury to the teeth, plain or alkalized water should be used immediately afterward.

Cynanche Maligna Ulcerosa.—In all forms of ulcerative sore throat, whether scarlatinal or otherwise, but especially when sloughing is present, and when there is marked general asthenia, hydrochloric acid is indicated as well locally as internally. It may be applied with a brush (1 part in 15 of liquid) or in gargle (2 dr. to 8 oz.). In gangrenous or "putrid" sore throat, the nearly pure acid may be carefully and lightly pencilled over the affected part.

Diphtheria.—Bretonneau recommended the application of the strong acid mixed only with a little honey to the false membranes and adjacent tissues, and this has sometimes arrested the local progress of the malady; but, on the other hand, it has sometimes done harm by exciting irritation, which has favored the development of membrane. A weaker solution, such as the dilute acid of the Pharmacopœia (1 in 3¼), is to be preferred, and much advantage has been traced to it (Dr. Heslop: *Medical Times*, i., 1858, p. 612). A *weaker* gargle (1 or 2 dr. in 8 oz.), as above mentioned, may be used if the conditions admit.

Therapeutical Action (Internal).—*Dyspepsia.*—There are two varieties of indigestion in which hydrochloric acid is especially indicated—the so-called "atonic" form, and the "acid" form—but the mode of its use is somewhat different for each.

Atonic dyspepsia occurs either in connection with general weakness or impaired hygienic conditions—for instance, in over-worked factory girls, seamstresses, etc.,—or in well-fed person who tax their stomach with too much nitrogenous food while leading a sedentary life. The secretion of gastric juice is but scanty, and the patient suffers from weight and heaviness after food, from general oppression, and other signs of unfinished digestion. One indication for the treatment of such a condition is to supply additional acid to the gastric secretion; but, as we have reason to believe that adding such acid *before* a meal will check the formation of

the naturally acid though scanty gastric juice, it is better to allow this to do what it can, and to prescribe our medicinal acid shortly *after* food has been taken, with the object of assisting nature, and not interfering unduly.[1]

In cases of "acid" dyspepsia, the patient suffers rather from heartburn and regurgitation of sour fluid, connected either with hyper-secretion from the gastric glands, or abnormal fermentation of starchy, saccharine, or fatty food. It is true that the symptoms may often be relieved by soda, but in many cases, more permanent relief will be given by dilute hydrochloric acid administered about half an hour before a meal. This will lessen the amount of the natural secretion, and will check fermentation.

It is only recently that this important distinction as to the *time* of taking an acid with reference to food has been recognized; many writers, Nothnagel for instance, are satisfied with recommending its use always before meals, and certainly if it be given after food, in cases of *pyrosis or water-brash*, it will aggravate the mischief; these are the true cases in which its use is indicated *before* meals, when it exerts an astringent action. It is contra-indicated in acute inflammatory, and also in organic disease; and in any case its use should not be continued too long, or the digestive property of the gastric juice will be impaired.

Headache, especially felt in the temple and brow, and marked giddiness are often connected with the dyspepsia above described, and are relieved by hydrochloric acid.

Diarrhœa.—In this complaint, hydrochloric is often preferred to other acids, not because it has a more energetic effect than, *e.g.*, sulphuric acid, but because it is better borne by the stomach. It is most reliable in cases that are due to abnormal fermentation in the bowels, with formation of lactic acid, as in what is called summer diarrhœa and gastric catarrh of infants; there are, however, many other remedies for this condition which must be considered better than the acid.

Fevers.—In typhoid or "low" fever, hydrochloric acid had, at one time, a high reputation; it was said to moderate the pyrexia, to limit the alteration of the blood, and to directly influence the morbid process. We scarcely expect so much now, but still there is reason to think that a judicious use of this acid may favor the assimilation of food, if it do not exert antiseptic influence. According to the investigation of Manassëin, with the gastric juice of fever patients, it is not *pepsine* that is deficient but *acid*, and this deficiency may be supplied for a time by the artificial acid, which then much aids the impaired digestion. It matters little

[1] Manassëin showed that in dogs made anæmic by blood-letting, the normal proportion of acid and pepsine was altered, and in such animals an addition of artificial acid to the gastric juice is, *ceteris paribus*, more effective than in the healthy (Virchow's Archiv, lv., p. 451).

whether we say with this observer, and with Chambers, that we supply deficient acid, or, with Richardson, that we neutralize by it super-abundant alkali formed during fever. Chambers records an emphatic opinion as to its value, after a fairly extensive use of it at St. Mary's Hospital, in "low" fever, apparently typhus and typhoid. The treatment by hydrochloric acid was more successful than by any other method, but we must add that he conjoined with the former, strict attention to *nourishment*, giving milk and beef-tea regularly every two hours, day and night (*Medical Times*, 1858; *Medico Chirurgical Review*, ii., 1863). Henderson has reported on its value during an epidemic at Shanghai (*Medical Times*, i., 1863). On the other hand, Dr. G. Johnson is satisfied with the far better progress made by his typhoid patients in King's College Hospital since he *omitted* wholly mineral acid from their treatment. He finds, especially, that diarrhœa is less troublesome, and considers that acids irritate the bowels, just as bread or meat would do (*British Medical Journal*, i., 1875). I cannot think Dr. Johnson's reasoning very conclusive, though his facts are of course to be accepted. I think the acid sometimes useful, and if well diluted the doses required will not irritate the bowels. It may be given as a refrigerant drink in lemonade, or mixed with essence of meat so as to aid assimilation.

Scarlet Fever.—There is also evidence as to the value of hydrochloric acid in scarlatina. Osborne records a prolonged experience in its favor (*Lancet*, ii., 1862), and more recently Egbert (Pennsylvania) has quoted nearly three hundred cases, all treated by a mixture containing this acid with chlorate of potash (Ranking, i., 1873). He gave about 8 min. of acid with 20 gr. of chlorate every two hours to a child of six, and more or less than this according to age. Occasionally Tinct. camph. co. was added to relieve restlessness; no applications were made to the throat, unless sometimes ice externally; only one death occurred. Of course it may be said that fevers tend to get well, and will do so under any treatment, but yet these results deserve careful attention. I myself constantly use hydrochloric acid internally and locally in cases of scarlet fever where there is marked general asthenia with dark ill-developed rash, and tendency to sloughing in the fauces (*v.* Chlorate of Potash).

Variola.—Dr. McDonald advocates the treatment of small-pox, both internally and externally, by this acid. He uses a lotion containing ʒ ss. ad ℥ x. liq., and finds it considerably relieve the cutaneous itching and irritation.

Urinary Deposits.—In oxaluria, Dr. Prout long ago recommended hydrochloric acid, and its use is especially indicated for the impaired digestive power, and the anxious and depressed mental condition usually connected with the malady (*v.* p. 197). It may be given *before* meals with a bitter, such as nux vomica or chirata, and continued till urates begin to appear in excess in the renal secretion. In cystic oxide and phos-

phatic deposits with alkaline urine, it is also useful, and has sometimes been injected into the bladder for its local effect (℥ij. ad ℨ iv. Aq.)

Gout.—Dr. Duncan recommended this acid as a preventive of the undue formation of lithic acid (*Dublin Quarterly Journal*, May, 1865) by its aiding assimilation; hence it should be serviceable in chronic gout, but such a view has not been supported by the experience of others, and, as a rule, gouty subjects are very intolerant of any acid treatment.

There are several other disorders in which hydrochloric acid is sometimes, though not generally used, but in which its good influence on the digestive tract may fairly be expected to relieve.

Pneumonia.—Traube states that he has found it useful in that form of pneumonia which sets in with much biliary disturbance—nausea, coated tongue, gastric catarrh, and diarrhœa.

Eczema.—Mr. Erichsen has published cases illustrating its value in chronic eczema (*London Medical Gazette*, 1846, p. 198), but in this, and in hepatic disorder, its value is better shown when in combination with nitric acid.

Syphilis.—The former reputation of this acid as a cure for syphilis (*Medical Quarterly Review*, 1835) in Vienna, need be mentioned only as an historical fact (Nothnagel). The aqua regia may, however, prove of service in chronic cachetic conditions.

Preparations and Dose.—*Acidum hydrochloricum dilutum:* dose, 10 to 30 min. freely diluted. *The strong acid*, given internally in an undiluted form, is an irritant poison.

[Preparations, U. S. P.—*Acidum muriaticum*, sp. gr. 1.160; *Acidum muriaticum dilutum:* muriatic acid 4 troyounces, distilled water, sufficient to make 1 pint.]

Adulterations.—Sulphurous and sulphuric acids, chlorine, and iron. The commercial acid is often colored from the presence of iron impurities.

ACIDUM NITRO-HYDROCHLORICUM DILUTUM—DILUTE NITRO-HYDROCHLORIC ACID—AQUA REGIA.

Preparation.—By mixing 3 parts of nitric, with 4 of hydrochloric acid, and afterward 25 of distilled water: the strong acids, *undiluted*, are left to act upon each other for twenty-four hours to insure complete decomposition and the full development of free chlorine.

$$2HNO_3 + 6HCl = 4H_2O + 2NO + 3Cl_2$$

At the same time two other compounds are formed—chloro-nitrous and chloro-nitric gas. If the acids be diluted *before* being mixed, the same reaction occurs, but requires several days for completion.

Characters and Test.—A colorless or yellowish liquid, with the odor of chlorine, volatile, and easily decomposed by light; sp. gr. 1.074. It has the power of dissolving gold, the king of metals—hence its old name, "aqua regia."

Physiological Action.—In its full strength this acid is irritant and corrosive; in moderate doses it has an alterative tonic action; it stimulates the glandular system, and is apt to cause salivation and also an increased flow of bile. Its actual chemical composition is not thoroughly known, and its difference in action from the other and simpler mineral acids has not yet been verified.

Therapeutical Action.—It is useful in many of the diseases mentioned under nitric acid, but seems to possess exceptional power to influence the liver and glandular structures of the alimentary canal.

Hepatic Disorder.—In hepatitis, not so much in the acute as in the chronic form of the malady, which usually ends in enlargement and induration, it has been praised by good authorities. Sir R. Martin strongly recommends its application by means of a bath, putting about 1½ oz. of acid to each gallon of water (*v.* Preparations). Two gallons represent an average quantity for a foot-bath, which should be used warm, and while the feet are immersed, the inner side of the limbs and the regions of liver and spleen should be sponged alternately for ten to fifteen minutes altogether. Martin recommended this bath morning and evening, but I have usually found an evening bath sufficient, and have seen excellent results from it; generally it has regulated the action of the bowels, and even produced laxative effects. Some patients are nauseated and weakened by its use, though they receive benefit: it requires watching, and smaller quantities of the acid should be tried first in delicate subjects. If it does not relax the bowels, an aperient should be taken occasionally during the course of the baths.

In hepatic torpor, or chronic catarrhal jaundice, if no inflammation be present, and in *chronic dysentery* with hepatic congestion, this form of bath is also valuable, and may be conjoined with the internal exhibition of the acid: even in *cirrhosis* and the consequent dropsy, benefit has been derived from this treatment.

Syphilis.—In the later stages of syphilitic cachexia, when the blood-condition is impaired, and elimination by the liver and skin is often inefficient, the acid used internally and in the form of bath has been recommended: a spare but nutritious diet should be enjoined in these cases.

Rachitis.—Attention has been drawn by Mr. Brodhurst to the value of nitro-hydrochloric acid baths in rickets (*Lancet*, ii., 1868); they should be conjoined with hygienic treatment, iron, and cod-liver oil.

Chronic Bronchitis.—When the expectoration is profuse and semi-purulent, sponging of chest and trunk with the acid solution already mentioned is said to give much relief (Dr. Waring, op. cit. p. 443).

Acne Rosacea.—A lotion containing the dilute acid, 1 or 2 dr. to 8 oz. of rose-water, is sometimes a useful stimulant to the affected part, and an acid foot-bath tends to relieve the internal congestions with which the disorder is generally associated.

Oxaluria.—This is, in most cases, dependent on some fault in primary digestion (I have known it produced apparently by continued use of a drinking water containing much lime), besides the renal symptoms, malaise, depression, and hypochondriacal feelings accompany the malady. Relief may be given by the mineral acids conjoined with attention to diet and drinking water; and of the different acids the nitro-hydrochloric seems to be the best, as originally stated by Dr. Prout ("Stomach Disease," p. 73); he advised its continuance for a few weeks at a time, or until lithates appeared in the urine. Deposits of cystine are relieved by the same treatment.

Sciatica—Rheumatism.—In the great majority of these cases, an alkaline rather than an acid treatment is indicated, but when they occur in connection with oxaluria the acid should be given (Fuller). In rheumatic gout in cachectic subjects it is also serviceable.

Dyspepsia.—In dyspepsia or "apepsia," connected with deficient action of the intestinal glands, and accompanied with a chronic looseness of the bowels, the acid has given very good results, used in the manner directed under hydrochloric acid.

Preparations and Dose.—*Acidum nitro-hydrochloricum dilutum:* dose, 5 to 20 min., freely diluted (it is liable to injure the teeth; they should therefore be cleansed with an alkaline wash or plain water).

Bath.—As a matter of convenience the bath may be prepared with six fluid ounces of the *dilute* nitro-hydrochloric acid added to each gallon of water in a wooden or porcelain vessel, but the more active formula of Sir R. Martin is the following:—Acid. nit. fort. ℥ ij., Acid. hydrochloric. fort. ℥ iij.; mix and allow to remain together for at least twelve hours; afterward add 5 oz. of water. Of this mixture 3 oz. should be used for each gallon of water: two gallons are an average quantity for a foot-bath. The bath may be kept in use for several days by adding ½ oz. of acid solution and 1 pint of water each time to compensate for evaporation, warming only as much as is necessary (96° to 98° F.). The towels and sponges used should be kept in cold water during the interval.

[Preparations, U. S. P.—*Acidum nitro-muriaticum:* nitric acid, 3 troyounces; muriatic acid 5 troyounces. *Acidum nitro-muriaticum dilutum:* nitric acid 1½ troyounce, muriatic acid 2½ troyounces; distilled water, sufficient to make 1 pint.]

Adulterations.—Chiefly sulphuric and hydrochloric acids.

ACIDUM HYDROCYANICUM DILUTUM—DILUTED HYDROCYANIC ACID, HCN or HCy,=27.

A solution in water containing 2 per cent. by weight of the anhydrous acid (Scheele's acid contains 4 to 5 per cent., Vauquelin's 3.3 per cent.).

Amygdalin and emulsin, from which the acid is developed, exist together in many plants; in the leaves of the cherry-laurel, the kernels of the peach, almond, cherry, etc. In the mineral kingdom the acid is found in combination as cyanate and cyanide; it occurs also in various animal secretions, and may be obtained by heating nitrogenized organic matter in contact with a base. Scheele discovered the acid in 1782, and is said to have been accidentally poisoned by it.

PREPARATION.—By distilling, with gentle heat, a mixture of ferrocyanide of potassium (yellow prussiate of potash) and dilute sulphuric acid. Half the cyanogen passes over into the water of a cooled receiver as hydrocyanic acid, and part remains in combination with potassium and iron as a yellowish-white insoluble double salt (Everitt's salt). Some acid sulphate of potassium is also formed: thus—$2K_4FeCy_6+6H_2SO_4=FeK_2FeCy_6+6KHSO_4+6HCy$.

CHARACTERS AND TESTS.—The pharmacopœial solution is a colorless volatile liquid of characteristic bitter-almond odor. Its taste has been variously described as "hot and bitter" (Taylor), or "cooling, afterward irritating" (R. W. Smith); sp. gr. 0.997 (nearly that of pure water). If free from other acid it reddens litmus but transiently. It loses strength on exposure to air and light, but that which is prepared by the pharmacopœial process and kept in dark-colored bottles may be retained for years without perceptible change. Stronger solutions alter more readily, and of the anhydrous acid (which has sp. gr. of 0.697) a part evaporates on paper so quickly as to freeze the rest. Cyanides prevent fermentation, and are fatal to vegetable life (Dumas).

1. *The White or Silver Test.*—Nitrate of silver gives, with prussic acid solutions, a dense flocculent white precipitate of cyanide of silver, insoluble in cold, soluble in *boiling* nitric acid—$HCy+AgNO_3=AgCy+HNO_3$. This test may be conveniently applied to the detection of prussic acid vapor by means of two watch glasses, the lower one containing a little of the suspected solution, and the upper one, inverted over it, a few minims of nitrate solution (1 gr. to the oz.): the latter soon becomes opalescent, and when dry, leaves a white stain, showing under the microscope prisms or long plates interlaced. Cyanide of silver, like other insoluble cyanides, may be further tested by placing it in a narrow glass tube drawn out at one end and heating: cyanogen will escape and may be lighted at the pointed end; it burns with a rose-colored flame, having a bluish halo.

2. *The Blue or Iron Test.*—This is applied by adding to the solution a little liquor potassæ and a few drops of a mixed solution of a proto- and per-salt of iron (protosulphate and perchloride are commonly used); a greenish-brown precipitate falls, which, on addition of a little dilute hydrochloric acid, becomes dark or Prussian blue in color. The potassic cyanide, first formed, gives rise to ferrocyanide and afterward to ferric cyanide with the iron salts, thus:

$$HCy+KHO=KCy+H_2O$$
$$2KCy+FeSO_4=FeCy_2+K_2SO_4$$
$$4KCy+FeCy_2=K_4FeCy_6$$
$$3(K_4FeCy_6)+2(Fe_2Cl_6)=12(KCl)+Fe_4(FeCy_6)_3$$

The acid dissolves any excess of precipitated iron oxides that might obscure the color.

3. *The Red or Sulphur Test.*—Add to the solution a few drops of ammonia and of yellow sulphide of ammonium; warm gently till colorless, and evaporate slowly; to the residue add a drop of acid solution of perchloride of iron; a blood-red color (sulphocyanide of iron, $Fe_2 6CyS$) is developed; it is discharged by corrosive sublimate, and thus distinguished from meconic acid. In this test some free sulphur in the ammonium sulphide unites with the alkaline cyanide to form sulphocyanate of ammonia.

$$2AmCy+S_2=2AmCyS.$$

The ammonia combines with excess of free sulphur, and forms, among other compounds, sulphydrate of ammonium, which should be removed by boiling and evaporation, and if this be not carried far enough, some of the latter compound remains and gives rise to black sulphide of iron instead of sulphocyanide on addition of the perchloride solution.

These two tests are also applicable to the vapor by means of watch glasses.

4. *The Copper Test.*—To the liquid, rendered slightly alkaline by liquor potassæ, add solution of sulphate of copper; a greenish-white precipitate falls, containing cyanate of potash and of copper with some blue oxide. When this is dissolved by a little hydrochloric acid, the precipitate becomes nearly white.

Absorption and Elimination.—Hydrocyanic acid is absorbed to some extent, even through the unbroken skin, especially if a strong solution be applied with friction; from a wound, or from mucous membrane, it is, however, absorbed much more readily. When placed on the tongue or swallowed in the ordinary way, it passes sooner into the circulation than when injected into the stomach, rectum, or vagina (Coullon, Krimer). In less than thirty-six seconds after a little of the strong acid is placed on an animal's tongue, it may be detected in the circulating blood (Krimer: *Horn's Archiv*, 1826): after intravenous injection, also, it quickly produces its effects, but most quickly after inhalation. Guinea-

pigs made to inhale the anhydrous acid for one second, die within fifteen seconds, and strong rabbits exposed to the vapor for three seconds, are destroyed within thirty (Preyer: "Die Blausäure," zw. Theil, 1870, s. 133). The weakly, the young, and the aged among warm-blooded animals are much more easily affected by the acid; while frogs, and all cold-blooded creatures, are much less sensitive to its action, and survive toxic doses for several hours. Horses are said to be insusceptible to quantities of one or two ounces (Amory: *Boston Journal*, 1866).

Although so rapidly poisonous to most animals as it is also to men, there is yet no difficulty in concluding that absorption must precede any general action, and Stillé has shown that if a tight ligature be placed round a limb exposed to the acid, constitutional effects do not occur, so long as the local is cut off from the general circulation (vol. ii., p. 222, 3d ed.). Ordinary blood is not essential to its action, for the bloodless "salt frog" exhibits the same symptoms under prussic acid as the normal creature (Lewisson: Reichert's *Archiv*, 1870.)

Elimination is rapid, and for ordinary medicinal doses is probably complete within an hour; even after a full or poisonous amount, if life can be prolonged for that time, recovery may be hoped for. The acid passes out partly by the saliva, to a slight extent by the kidneys, but mainly by the lungs, as evidenced by the characteristic odor of the breath.

Physiological Action (Internal).—*Digestive System.*—Small medicinal doses—2 to 5 min. of the officinal acid—seldom exert more than a transient effect of sedative character on the gastric mucous membrane; 10 to 20 min. induce local irritation of the fauces and stomach, with increased flow of saliva and nausea; breathing the vapor, or taking by the mouth 20 to 30 min. of more of the diluted acid, causes such symptoms in a marked degree, though not always immediately (Taylor).

Toxic Action.—If, with animals, such doses be used as allow time for a somewhat gradual poisoning, vertigo is noted as an early symptom, with loss of power over the muscles, so that the animal quickly falls; the breathing, at first perhaps hurried and panting, soon becomes slow and difficult, while the heart-beats are rapid and weak. Convulsions mark (according to Preyer) the *second* stage of cyanic poisoning; they may be tonic or clonic, and affect not only the limbs, but the respiratory muscles and the heart: livid features, protruding shining eyeballs, and congested veins evidence the obstructed circulation, and either death soon comes from asphyxia, or after a period of paralysis and torpor, recovery gradually ensues. Evacuations from the bladder and bowel commonly occur during the unconscious stage, and a peculiar shriek often, though not always, precedes death. *Post-mortem*, intense congestion of the larger venous trunks and the cerebral membranes is the most marked appearance.

In man, more than 60 min. of the dilute, or 1 gr. of the anhydrous acid, will be usually a fatal dose, though symptoms may not be developed for some minutes; after as much as ½ fl. oz., however, they will come on in a few seconds, or even during the act of swallowing. Volition and power may be retained just long enough to walk a few paces, to arrange the bed-clothes, or to cork a phial; but suddenly the subject, if standing, will fall prostrate, often with a scream or in convulsions. Within two minutes he will be insensible, paralyzed, with fixed and glistening eyes, dilated insensible pupils, cold clammy skin, and swollen cyanotic face: the jaw is set, saliva exudes from the mouth, and evacuations occur from the bladder and bowel: the breathing, at first perhaps hurried, soon becomes convulsive and gasping, with long pauses and prolonged expiration: the pulse, after a brief quickening, is soon imperceptible, and death occurs by asphyxia within three to five minutes from the fatal dose.[1]

Respiratory System.—In man, ordinary medicinal doses do not affect respiration, but 10 to 20 min. may render it irregular and labored. Under small doses, the breathing-rate of animals either remains unaltered at first, or is markedly lowered; it is never increased. With larger doses and concentrated solutions, the course of poisoning is so rapid that respirations can scarcely be counted; convulsive movements also interfere with observation, but we can say that in this stage the rate is lowered, and continues so. As the animal passes into a comatose condition, a slight rise may occur, which increases if recovery is proceeding, but which soon gives place to a marked slowing and then complete cessation of breathing. The heart may continue to beat for some little time after this, and if so, even if in other respects the animal seems dead, *artificial respiration* will restore it to life.

The general character of the respiratory changes resembles (according to Preyer), not that occurring in apnœa, but that which occurs when the vagi are divided and the cut end of the central branch is stimulated, or irritated, by electricity. At the beginning of the poisoning the inspirations are deeper than normal, then follows a pause, and then short shallow expirations. In many instances during the convulsive stage there occurs on inspiration a tetanic spasm of the diaphragm, such as Traube found after direct vagus irritation.

Nervous System.—Doses which disturb the digestive and circulatory systems—10 to 20 min.—may cause not only giddiness, but also a sense of constriction and heaviness of the head, prominence of the eyes, some confusion of intellect, and muscular weakness. Upon which part of the

[1] The glistening condition of the eye usually described, and the evacuation of the bladder and bowel, are not, I think, so constant as commonly supposed: in four cases within my experience, the former symptom was not present, and in only one did the evacuations occur.

nervous system the special effects of larger doses are exerted—whether upon the vagus, the nerve-centres, or the peripheral nerves—has been disputed.

Vagus Nerve.—Arguing from the conditions already described, and from the fact that poisoning by prussic acid is most rapid if the vapor be inhaled, Preyer concluded that its chief action was exerted on the vagus *terminals* in the lungs, stimulation, or rather irritation of them being propagated to the respiratory centre, and causing the phenomena of asphyxia. That the stimulation was not, in normal conditions, exerted directly on the respiratory *centre* he held to be evident from the fact, already noted, that section of the vagi—*i.e.*, interruption of communication between the ends and the centre—delayed the course of the poisoning and the time of death: the occasional occurrence of tetanic spasm of diaphragm he explained by a secondary transfer of irritation from the medulla to the *phrenic nerve.* In animals with divided vagi, the respiratory changes were somewhat different, and death in such cases was explained either by an action on the terminals of other (unknown) nerves of the lungs, or by direct action on the centre in the medulla, or when occurring under large doses, by direct paralysis of the heart.

Nerve-Centres.—On the other hand, Boehm and Knie, conclude that the main change is always exerted on the *central* nervous system—the medulla—the functions of which are for a brief period stimulated and then destroyed (*Archiv für Exper. Path. Klebs.*, Bd. ii., p. 137). In cats prepared for experiment according to their method, there occur under prussic acid at first two to four deep labored inspirations, then quick and convulsive expiration, "resembling that caused by irritation of the superior laryngeal nerve" (Rosenthal); they observe no inspiratory cramp or tetanus, and no influence of the vagi, whether it be left entire or divided, upon the course of the poisoning, nor upon the heart (*v.* p. 268). (The practical result is that these observers attach no value to atropia as an antidote, though equally with Preyer they recognize the excellent results to be obtained by *artificial respiration.*)

I am not prepared to reconcile the differences between these and other observations, but in a more recent essay Preyer attributes the differences to *undue manipulation* of the animals, maintains his conclusions unaltered, and offers additional facts in support of some of them (*Archiv für Exper. Path. Klebs.*, April, 1875). We must add, however, that Lecorché and Meuriot, while agreeing with him that cyanic death is connected with intense excitation of the vagus nerve, and that section of the vagi delays it, yet attribute such excitation to a *central*, not peripheral, action of the poison. A striking experiment made by Prof. Jones bears in the same direction: having found, with alligators, that the internal giving of the poison did not easily or quickly take effect, he applied it *directly* to the medulla oblongata, and within sixty seconds there followed complete ex-

piration of the air contained in the lungs, with collapse of those organs, and tetanic contraction of the respiratory muscles (New York *Medical Record*, vol. ii.).

The convulsions which often occur in cyanic poisoning are *cerebral* in origin, for they do not occur in parts situated below a transverse section of the spinal cord—*i.e.*, in parts with which cerebral communication has been interrupted (H. C. Wood). We may further conclude that they are connected with disturbed cerebral circulation, for they have been noticed to commence directly after cardiac arrest (Laschkewitsch, Coze).

Peripheral Nerves and Muscles.—We are unable to conclude positively with Preyer that the peripheral ends of the vagus receive the first and main influence of the poison, for the mere extent of absorbing surface and ready contact with blood in the lungs would go far to account for the greater rapidity of the effects of inhalation, and there is other evidence that the respiratory *centres* are affected. This question, however, apart, we may accept the careful observations of Kölliker, that peripheral sensory nerves are paralyzed by *local contact* with sufficiently strong solutions, and the early disappearance of reflex function in cyanic poisoning is connected with such paralysis rather than with paralysis of the cord (Kiedrowski). Nerve-tissue placed in a solution of prussic acid loses its conducting power, and muscular tissue loses its irritability still more quickly, although the nerve-trunks are probably acted upon at the same time as the muscles after internal administration of the acid (Virchow's *Archiv*, Bd. x., p. 272). When the whole blood is rendered venous, as in later stages of poisoning, there is increased action of the contractile fibres of organic life (involuntary muscular tissue), and hence, often increased peristalsis of the intestine, contraction of the bladder, and evacuations from those viscera. The same result occurs sometimes in asphyxia from hanging, carbonic acid poisoning, etc., and is commonly attributed to the same cause (venosity of blood), though indeed it *may* result from *paralysis* of sphincters, as it does under chloroform, or during an epileptic attack.

Circulatory System.—Continued small doses—1 to 5 min.—given at moderate intervals of two to four hours, lessen the force and rapidity of the heart-action: 10 to 20 min. taken by the mouth, or inhaled, may cause giddiness and faintness, with slowing, or sometimes quickening, of the pulse, and suffusion of the face. With animals, full or large doses cause a sudden arrest in diastole; this continues for a variable time, and is followed by quickened action, and afterward by diminution, and then by either gradual return to the normal number of beats, or total cessation according to the dose, and to the age, strength, etc., of the animals (Laschkewitsch, Preyer).

A point of much interest is the statement that *section of the vagi* in the neck prevents this primary diastolic arrest, and Preyer, who has

studied the subject with the greatest care, and has made very numerous experiments, affirms that after such section, no slowing of the heart-action occurs under doses that would with uncut vagi stop the heart (Op. cit., erst. Theil, 1868, p. 35); also that death, under toxic doses, is much slower when these nerves are divided than when they are not. We know from Pflüger's researches that weak stimulation of the vagus causes slowing of the heart, and a very strong stimulus of it causes stoppage in diastole, and Preyer argues that the action of prussic acid on the heart is exerted through the *vagi* in accordance with these results, and the secondary and temporary quickening which occurs with certain doses is due to a secondary paralysis of the control-influence of the same nerves.

On the other hand, we have directly contradictory observations upon cats by Boehm and Knie, who found no primary diastolic arrest, and no influence exerted either way by section of the pneumogastrics; but their animals, though more accurately dosed, were in still less natural condition than those of Preyer, for they were chloralized, tracheotomized, and injected through an exposed jugular vein: we cannot think their observations conclusive (*v.* p. 265).

With very large toxic doses death is instantaneous, and the heart is arrested in diastole without any recurrence of ventricular contraction, though some movement of the auricles may be perceived on opening the chest (Lecorché and Meuriot, *Archives Gén.*, t. xi., 6c série): with such doses the result is not influenced by section of the vagi, and death is presumed to follow direct cardiac paralysis (Preyer). Applied directly to the heart, the acid arrests its movement and destroys its muscular irritability.

Arterial Pressure in the vessels is said to be increased under the action of prussic acid (Wahl), but according to Boehm and Knie, such increase is temporary only; the pressure soons falls below normal, and after large doses remains so for some time.

The startling rapidity of action of prussic acid suggests an immediate toxic effect on the *blood*, and there is indeed a remarkable color-change induced, which has been thought to give a clue to the intimate working of the poison. Thus, if the jugular vein of a rabbit be exposed, and seen to contain dark blood, and a toxic dose of acid be then given by the mouth, so soon as convulsive movements indicate its taking effect, will the stream of venous blood take on a clear red color, and the vessel greatly enlarge in size. If the blood be let flow from an incision, a similar change is observed, and if the right heart be examined *in sitû*, the dark blood contained in it is equally seen to become red; it is so also in the nose and ears (Gaethgens: *Med.-Chem. Untersuch.*, drit. Heft., Berlin, 1868, Hoppe-Seyler). This had been noticed, though with less detail, by earlier observers, by Vietz and others, by Claude Bernard (who got a similar result with carbonic oxide), and by Preyer, who found the same appearance caused not

only by diluted sulphuretted hydrogen, but also by the mere removal of any obstructions placed in the air-passages (Op. cit., p. 88). It is not therefore, due to a specific action of prussic acid, but is secondary to altered respiration, and although very interesting, has not the importance attached to it by Gaethgens. The apparently contradictory observations of Bischoff and others, to the effect that all the blood found in the body after cyanic poisoning is unusually dark and venous, are explained by a difference mainly in the *rapidity* of the poisonous action: if life be prolonged for a few minutes, the red color is gradually replaced by dark, while if death be very sudden, red blood only is found in the heart—sometimes even on the following day (C. Bernard). In cold-blooded animals, the red color persists much longer than in the warm-blooded (Preyer).

Theory of Action.—It is easier to ascertain, than it is at present to explain these facts. Hoppe-Seyler suggests that the red corpuscles lose for a time their power of giving up oxygen in the capillaries—that oxidation of tissue is suspended (*Untersuchungen*, 1866, erst. Heft, s. 140). Geinitz argued that a change in the *physical form* of the corpuscles would explain change of color, and found that the acid mixed with blood *outside* the body caused various alterations of their form (Pflüger's *Archiv*, Bd. iii., 1870): but according to Preyer the blood of a poisoned animal taken from the vessels directly after death, and examined by the microscope, exhibits *no change* in the character of the corpuscles (Chemismus, Leipsic, 1840). He inquires whether the deepened breathing could for a time induce a hyper-oxygenated condition, as in animals dying from apnœa and found by Pflüger to have light-red blood (*Archiv*, i., p. 106), or whether the increased blood-pressure could drive the blood so quickly through the capillaries as to prevent its giving up oxygen as usual.

I cannot satisfy myself as to a clear explanation, but believe that during the first stage of cyanic poisoning oxidation is arrested, and that the venous condition of blood found in later stages of poisoning is connected with spasm of the pulmonary arterioles, and paralysis of the respiratory and cardiac muscles.

It would seem that no *permanent* toxic combination is found with the corpuscles; they are not at once fatally spoiled, nor is oxygen wholly driven out, but for the moment (and it may be finally) its interchange with tissues is prevented. The results of many careful spectroscopic examinations by Preyer and others, and of many laborious gas analyses by Gaethgens, confirm this view: the red blood shows still the absorption bands of oxyhæmoglobin, and the dark blood those of hæmoglobin, with little or no combined oxygen: outside the body, indeed, prussic acid destroys hæmoglobin (forming a new compound, cyanohæmoglobin, which is destitute of ozonizing power), but apparently does not do so during life. Laschkewitsch could not detect such compound, but on the contrary found oxyhæmoglobin (Reichert's *Archiv*, 1868), and more recently, Hil-

ler and Wagner, examining blood while still within the mesenteric vessels, obtained characteristic though feeble lines of oxyhæmoglobin (*Lancet*, ii., 1877). If withdrawn from the body, the dark blood, shaken up with oxygen, resumes its normal red tint, and a most important practical point—the condition just described may be remedied during life by securing access of additional oxygen by *artificial respiration*.

Gaethgens proved (1) that the property of de-oxygenated blood to abstract oxygen from surrounding media is not destroyed by prussic acid; (2) that blood saturated with oxygen exposed to the action of prussic acid gives off no oxygen, and that substances which would usually withdraw oxygen from fresh blood do so with much difficulty under the influence of the acid. Both oxygen and carbonic acid are excreted in less than normal *total* quantity during the poisoning (on account of the slow rate of the breathing), but not only is the actual percentage of carbonic acid in the expired air less than normal, but the *percentage* of oxygen in the same expired air is greater than normal—*i.e.*, it has not been used up in the system.

Synergists.—Cyanides owe their activity to prussic acid, and exert a similar action. Cherry-laurel water, and essence of bitter almonds, owe their chief properties to the same acid. All substances which hinder hæmatosis, or the union of oxygen with the blood-corpuscles—such as arsenic, antimony, and most sedatives—favor the action of hydrocyanic acid.

Antagonists—Incompatibles.—The effect of medicinal doses is lessened by diffusible stimulants, by strong acids or alkalies, and by opium (Gubler). Warmth quickly volatilizes the acid, otherwise it favors its action. The most dependable antidote to poisonous doses is *oxygen*, which is best introduced into the system by *artificial respiration*.

Preyer strongly recommends atropia as a "dynamic antidote," since it acts upon the vagus nerve in a manner contrary to that of hydrocyanic acid (*v.* Vegetable Kingdom). I must agree with Boehm and others that his observations are somewhat wanting in scientific accuracy, as when he speaks of injecting "a little atropia," or says simply, "Injected sulphate of atropia, and afterward a rather large dose of prussic acid, which would assuredly have caused death" ("Versuche," p. 74, 36–37), and although Bartholow, Lecorché, and others have failed to obtain confirmative evidence, still they hold true to a certain extent. A practical difficulty in their useful application must always be the extremely rapid course of cyanic poisoning, and the (comparatively) slow diffusion of atropia; to be of any service, the alkaloid would have to be used almost on the instant of poisoning.

Sal-ammoniac was strongly recommended by J. Murray (*Edinburgh Philosophical Journal*, 1822), and although Orfila and Elwert showed that it could not be depended upon as an antidote, I think this and other

compounds of ammonia well deserve further trial. Modern observation credits the drug with a power of directly stimulating the respiratory centres (*v.* p. 255), and this, in addition to its general stimulating power, seems specially to indicate its use in cyanic poisoning.

Chlorine and chlorine water have been used with advantage by A. Chevallier and Orfila, but they are not manageable. Turpentine, though recommended as a specific antidote, has only value as a stimulant. I cannot see that phosphorus offers a resource of value, nor can much be expected from coffee.

Some indefinite evidence exists as to an antidotal power possessed by strychnia. Thus, a puppy that had taken ½ gr. of prussic acid quickly recovered after swallowing a dose of the alkaloid (*Medical Times*, ii., 1859), and some other instances are reported (*Lancet*, i., 1868). Stannius also found that strychnia-convulsions were modified by the acid, but Dr. Lauder Brunton concluded "that although the acid may somewhat lessen the convulsion, it cannot be employed as an antidote to strychnia with any hope of success," and G. Harley thought "that it rather hastened death from strychnia" (*Medical Times*, ii., 1861).

Silver and metallic oxides generally, form insoluble compounds with prussic acid, and fresh proto-carbonate of iron has been recommended as antidotal by Messrs. Smith ("Medico-Chirurgical Transactions," ii., 1865); practically, however, their influence can scarcely be exerted quickly enough.

It remains that *artificial respiration* is the main resource in all forms and stages of cyanic poisoning—it may be carried out in the ordinary methods, or excited by the sudden affusion of water, first cold and then hot, thrown over head and chest. This does not exclude the use of an emetic, the application of ammonia to the nostrils, or even its injection into the veins, while stimulating frictions and warmth should be applied to the limbs; by the steady use of these means, patients have revived from apparently hopeless insensibility, and if life can be prolonged for an hour, the chances of recovery become greatly increased.

Therapeutical Action (External).—*Urticaria*—*Prurigo.*—I have seen great relief given, even in obstinate forms of these maladies, by lotions containing hydrocyanic acid in sufficient strength. Pereira states that he did not observe relief in such cases, but he seems to have used only 2 dr. of acid in ½ pint of water. I have recommended ½ oz. or more in 10 oz. of liquid (rose water), and have never seen ill effects, but such a remedy should not be placed in careless hands, nor ordered if the skin be excoriated; *sometimes* a much smaller proportion will answer well, and especially when mixed with lead or soda lotion. The cyanide of potassium has also been used for lotion and ointment in the strength of ½ dr. to 8 oz. of liquid, or 1 oz. of cerate; a greater strength has caused severe irritation.

Headache—Neuralgia.—Trousseau used a lotion of cyanide locally in cases of sick headache, and Fuller recommended the painting of neuralgic parts with a strong preparation of the acid (½ oz. with 2 dr. each of glycerin and water), but such applications have rightly fallen into disuse.

Eye Diseases.—The same may be said of cyanic lotions and vapors in the treatment of eye disease, for which at one time they were in vogue. J. V. Solomon recorded numerous cases of conjunctivitis (sub-acute), ophthalmia, iritis, photophobia, etc., which were relieved by applications of dilute Scheele's acid, 1 part in 3 (*Medical Times*, i., 1852). Turnbull invented an instrument for applying the strong vapor to the eye, but this sometimes produced serious symptoms; in one case of its use, Sir W. Wilde describes faintness, giddiness, and unconsciousness (*Medical Times*, i., 1861). Nunnely records that he found strong applications to the conjunctiva poison as quickly as by the stomach ("Transactions Prov. Med. Surg. Association," N. S., iii., p. 58).

Ringworm.—Dr. Gee has found advantage from a lotion containing ½ oz. of sulphocyanide of potassium in 7 oz. of water with 1 oz. of glycerin, kept applied to the scalp. The effect must be watched, and a daily washing with soap and water practised.

THERAPEUTICAL ACTION (INTERNAL).—Hydrocyanic acid has a certain value in relieving spasmodic pain and irritation, but its use is limited by the extreme care required in dosage, and the risk of causing unpleasant symptoms; yet to say with Trousseau that "it is often dangerous, almost always useless, and very rarely curative," greatly overstates the facts.

Gastrodynia—Enterodynia.—Cases described under these names, and which seem to be frequently of neuralgic type, are often quickly relieved by suitable doses of prussic acid. Pereira gives instances of very severe spasmodic pain, where there was no complaint of pyrexia, of faintness, nor of any ordinary symptoms of dyspepsia; the pain was such as to lead to suspicion of organic disease, but it disappeared under the use of the acid. In one case it was seated in the intestine, came on about 2 P.M., and lasted until night, unrelieved by many remedies until this one was used, and Pereira made the further observation that its action is exerted quickly, and either produces complete relief or none at all. Sir T. Watson "has seen more rapid and decided relief from it in gastrodynia than from anything else."

Dyspepsia.—Dr. Elliotson, in a special treatise on the subject, makes several groups of cases in which he found prussic acid extremely useful; some were marked by pain and tenderness only, others by flatulence, nausea, anorexia, liver-troubles, and vertigo, others again by pyrosis, heartburn, and palpitation (*Medico-Chirurgical Review*, i., 1821). A. T. Thompson made somewhat similar observations, especially noting benefit when the tongue was hot, red, and sore (Dispensatory). Bailey

also published illustrative cases (*London Medical Repository*, 1828), and alluded to its value when there was sympathetic heart-disturbance, palpitation, etc. In such cases, it is still in frequent use, although other remedies may be required if there be marked symptoms of unhealthy secretion. Disappointment as to its effects may be sometimes traced to the inertness from age of the preparation, or to admixture with other drugs.

Vomiting.—The acid is useful in the vomiting of fever, and in sympathetic vomiting, and is sometimes indicated in that of ordinary gastric derangement: it may be added to effervescent mixtures, or to bismuth, but as a rule is better given alone in distilled water. In some patients, or in some conditions, and more especially when the dose is too large, nausea and vomiting seem to be increased or caused by the drug, and then it is better omitted: on the other hand, I have seen severe cases recover with 6 to 8 min. doses, when smaller doses and all ordinary means had failed. In simple intestinal obstruction, even when fæcal vomiting had occurred, I have used 10 min. doses with the effect of staying the vomiting, but care is necessary in watching the results. Dr. Brinton found the acid useful in the vomiting of gastric ulcer; Dr. Harley combined it with bismuth, opium, etc., in that of enteric fever; Pereira recommended it in the vomiting and purging of phthisis, and even of cholera, and it may well be tried in the "nervous" form of vomiting, that connected with pregnancy, or with cerebral concussion or disorder.

Phthisis.—In the early part of this century Dr. Granville published a small treatise "to establish the claims of a new and powerful remedy," and in his second edition (1820) congratulates himself on the conclusive and numerous facts which have proved he was "not indulging in the chimeras of a revery" when he recommended the prussic acid for treating, if not curing, consumption. Being before the days of physical diagnosis, his cases scarcely bear examination, and his peculiar egotistic style jars upon the professional reader; but he may be credited with pointing out the relief often given to the general nervous irritability, the dyspepsia and harrassing cough of phthisical subjects. The exaggerated views entertained both by the eminent Majendie and by Granville as to its powers of checking the disorder and curing asthma, chronic cough, etc., have not been verified by later experience. We can only say that it is a useful palliative for the irritative dry cough, especially in cases when morphia is not suitable, and that with alkalies and calumba it is often serviceable in phthisical dyspepsia.

Whooping-Cough—"Nervous Cough."—Dr. Granville states, "without presumption," that in almost every case of whooping-cough this medicine, given early, removes the disease (p. 64), and Dr. Hamilton Roe, in a special treatise (1838), records equally excellent results. He was rather in advance of his time in concluding pertussis to be not always

inflammatory, but "a nervous affection, having its seat in the mucous membrane of the bronchi and the pneumogastric nerve," and for the "nervous element," *i.e.*, the peculiar whooping or spasmodic cough, he valued prussic acid more than opium, belladonna, or any other remedies then in use: he gave very full doses, such as ¾ min. of Scheele's acid to infants, and 1½ drop every quarter-hour for twelve hours to a child of ten years. I think this another illustration of the benefit to be obtained from the medicine when it may be justifiably and yet cautiously pressed, but for average practice it would be dangerous, and I agree with Sir T. Watson, who thinks the remedy in such doses "too gigantic for such young subjects;" also with Dr. C. West, who finds it "sometimes magical" for diminishing the frequency and severity of the paroxysm, but sometimes inert, sometimes poisonous. Dr. Atlee, judging from two hundred cases, gives a most favorable report of it (*American Journal*, vol. x.), and my own experience is decidedly in the same direction—the more purely nervous the paroxysms, the better will the remedy act, though some difficulty in graduating its dose will always remain: also, as is well known, the results obtained from remedies unaccountably vary in different epidemics and different individuals. In other forms of irritative cough, connected with spinal or vagus irritation, I have seen more benefit from this acid than from any ordinary sedatives; and the long-recognized clinical value of the drug in such conditions is of marked interest taken in connection with the special effect on the medulla and vagus, mentioned under physiological action.

Asthma.—Much relief may be given to patients suffering from simple spasmodic asthma, by small and repeated doses of prussic acid.

Palpitation.—Whether palpitation arises from cardiac hypertrophy or from ordinary functional derangement of the heart, dependent upon nervous exhaustion or dyspepsia, hydrocyanic acid will often prove useful.

Vertigo—Cerebral Irritation—Mania.—The acid certainly exerts some control over exalted cerebral function, whether by acting through the circulation or otherwise. Vertigo, especially, if dependent on gastric derangement, may be relieved by it. Dr. McLeod has furnished evidence of its calmative power in acute mania and acute melancholia, recording forty cases, in most of which the relief given to violent excitement was marked and rapid; about 5 min. of Scheele's acid was the usual dose, or 3 min. injected under the skin (*Medical Times*, i., 1862).

In Delirium Tremens, Dr. Dow has seen it serviceable (*British Medical Journal*, i., 1873), and Dr. Maudsley recommends its combination with digitalis (*Practitioner*, January, 1869, vol. ix.).

Preparations and Dose.—*Acidum hydrocyanicum dilutum* (contains 2 per cent. of anhydrous acid): dose, 2 to 8 min. *Vapor acidi hydrocyanici* (inhalation) is prepared with 10 to 15 min. in 1 fl. dr. of

cold water. "Mix in a suitable apparatus, and let the vapor that arises be inhaled." *Lotio:* 2 dr. to ½ oz. in ½ pint of rose water; it should not be applied to an abraded skin. Anhydrous prussic acid being one of the most active and rapid poisons known, should never be prescribed; neither should Scheele's prussic acid, which contains 4 per cent. of anhydrous acid.

[Preparation, U.S.P.—*Acidum hydrocyanicum dilutum*, contains 2 per cent. of anhydrous acid.]

ACIDUM NITRICUM—NITRIC ACID—AQUA FORTIS, HNO_3, =63.

Nitric acid, the highest known oxide of nitrogen, may be detected in the atmosphere after thunder-storms, for electricity determines the necessary combination of the gases. United with potash, soda, lime, or ammonia, it forms a nitrate which is found native in efflorescence on the soil of some countries; it occurs, also, in some minerals and in certain plants, *e.g.*, as potash nitrate in pareira root.

Preparation.—Being a volatile acid, it may be prepared from any nitrate (usually a nitrate of potash or soda), by distilling it with the more stable sulphuric acid, when sulphate of potash is formed, and nitric acid being set free, rises with the vapor of water and condenses in the receiver. $KNO_3 + H_2SO_4 = HNO_3 + KHSO_4$. Of anhydrous acid, it contains 60 per cent.

The dilute nitric acid contains 6 oz. of the strong acid in 31 oz. of distilled water, or about 1 min. in every 5 min. Heat is developed during its preparation, and condensation of volume occurs.

Characters and Tests.—The pure acid, protected from light, remains colorless, but if exposed becomes yellowish in color, from development of orange-colored oxides, mainly N_2O_4 (nitric peroxide); at a sp. gr. of 1.42 it is a stable compound, boils at 250°, and distils over unchanged; it has a very sour, corrosive taste, and an acrid, suffocating odor; its affinity for water is great, and the white fumes which it emits on exposure are caused by the combination of its invisible vapor with atmospheric moisture forming a cloud of minute drops.

A good test for nitric acid is its action on metallic copper or iron; when *undiluted* and poured on them, it gives dense red vapors of peroxide of nitrogen and other oxides, but if first *diluted*, a colorless gas, nitric oxide, NO, is given off, which changes into peroxide, N_2O_4, and becomes orange-red in color on contact with the air. If the colorless gas, NO, be passed into a solution of protosulphate of iron, it will com-

bine with a portion of it, causing a dark brown color. Morphia and brucia are colored bright red by the acid.

There is no precipitation test for nitric acid, because all neutral nitrates are soluble, but its adulteration with sulphuric or hydrochloric acid is detected by chloride of barium and nitrate of silver respectively.

Nitric acid is a powerful oxidizing agent, and is used in pharmacy to prepare the nitrates of different metals; also for the making of certain organic compounds, as gun-cotton, nitrite of amyl, etc.

Absorption and Elimination.—Dilute nitric acid in medicinal doses is diffusible and readily absorbed. In the blood it either combines with alkaline bases forming nitrates, or it circulates in a free state, or loosely joined (*invisqué*) with albumen (Gubler): it cannot be detected *free* in the blood by analysis. It is eliminated mainly by the urine as nitrate of potash or soda, not as free acid; yet it highly increases the acidity of the secretion by liberating acids weaker than itself (such as uric and lactic acids) from their combinations. From its effects upon the intestinal glandular structure, and from the comparatively small amount passed in the urine, it is probable that some is excreted by the lower bowel.

Physiological Action (External).—Strong nitric acid applied but for a moment, stains organic tissue yellow, and leads to desquamation of the epidermis; if applied firmly and for longer time, it exerts a potent caustic effect, due to abstraction of the water from the tissues and combination of the acid with alkaline bases; xanthfo-proteic or -picric acid is also formed, and the part becomes yellow.

Dilute solutions exert a stimulant, moderately astringent effect; by continued contact they change most animal and vegetable substances into oxalic, malic, or carbonic acids (H. C. Wood: "Elements," 2d ed., p. 96). Nitric peroxide is an efficient but irritating disinfectant.

Physiological Action (Internal).—For a general statement as to the action of acids on the organism, reference may be made to hydrochloric acid.

Digestive System.—Given internally, in medicinal doses, dilute nitric acid exerts a stimulant effect on the glandular system of the alimentary canal, and some tonic bracing effect on the mucous membrane, so that appetite is improved by it, and undue secretion lessened; this is probably owing to a direct local action. Salivation sometimes occurs under the use of nitric acid, either in consequence of the gastric irritation, or of direct stimulation of the salivary glands by the medicine. It is commonly credited with some power of stimulating the secretion and excretion of bile.

Large doses act like other violently corrosive irritant poisons. In a case that proved fatal on the eighth day after swallowing 1 dr. of the strong acid, the œsophagus and stomach were found inflamed and ulcerated, the colon was in the same state, but the small intestine was sound; suppression of urine had occurred.

SYNERGISTS—ANTAGONISTS.—The same as those of sulphuric acid.

THERAPEUTICAL ACTION (EXTERNAL).—*Disinfectant.*—Nitrous fumes may be generated by the action of sulphuric acid on nitrate of potash. They efficiently disinfect unhealthy wards, prisons, etc., but the use of less irritating substances has practically replaced this method.

Phagedænic Ulceration.—In cases of sloughing chancre, of phagedæna, of hospital gangrene, etc., when it is necessary to destroy portions of diseased tissue, and to stimulate to healthy action, strong nitric acid is one of the best caustics in use. The affected part should be cleansed and dried, so that the acid be not too diluted by secretion, the neighboring parts should be protected by oil or ointment, and the caustic then thoroughly applied with a glass brush, splinter of wood, or pledget of lint, until a firm dry yellowish mass is formed; the pain is at first severe, but soon subsides under cold water dressings, the eschar formed is not very deep, and usually separates in one or two days; the application may sometimes require to be repeated.

Bubo.—The strong acid may, with advantage, be lightly pencilled over torpid suppurating buboes, to destroy the integument and stimulate to healthy discharge; should a sinus be formed, the upper wall should be touched in the same manner (*Lancet*, ii., 1867, p. 796).

Lupus.—The same application is indicated for the indolent edges of an ulcerating lupus, though acid nitrate of mercury is perhaps better.

Uterine Disease.—Dr. Lombe Atthill has had the best results from applications of strong nitric acid to the interior of the uterus, in cases of fungoid granulation and excessive hemorrhage: lint bound on a uterine probe conveys the caustic through a small speculum placed in the cervix (*Obstetrical Journal*, June, 1873, and Treatise). It is a good application also in chronic inflammatory disease of the same part and in granular erosion of cervix if there be not excessive tenderness (*British Medical Journal*, i., 1876). H. Lee has found the acid good in uterine disease, if the mucous membrane be not too much thickened; it is important that it be not diluted by secretion, and that an alkaline injection be used after it (*Lancet*, i., 1874). As injurious effects have sometimes followed the use of nitrate of mercury and of strong iron solutions, I myself prefer the nitric acid for vaginal and uterine disease of the kinds named, but in cases of hemorrhage from the vagina or uterine neck, connected, *e.g.*, with carcinoma, I think the perchloride or persulphate of iron mixed with glycerin, are better hæmostatics.

Internal Hæmorrhoids.—It has been thought that strong nitric acid would supersede all operative interference in this disorder, but its curative power is really somewhat limited.

Its local application is only useful in small granular piles, and in "velvety" conditions of the mucous membrane; it checks the bleeding, but severe hemorrhage may occur when the slough separates. One or two

applications ought to suffice for the cure of such a condition, but for large masses, or for hæmorrhoids with narrow vascular attachments, other treatment is better. Billroth, however, reports much success with nitric acid in most forms of internal hæmorrhoids, but especially in the flat form: after protrusion, he applies the remedy till the part is "stiff and yellowish-gray in color," and then oils it well—he notes the importance of not touching sound parts with the acid, for it causes great pain (Ranking, i., 1872). Dr. Houston first proposed this treatment (*Dublin Medical Journal*, vols. xxiii.–xxvi.); and Mr. Henry Smith has used it extensively, and written in its favor.

In less severe cases where the parts bleed and are somewhat swollen, Dr. Ringer recommends a lotion containing 1 to 1½ dr. dilute acid to ½ pint water.

Prolapsus Recti.—If the strong acid be applied in one or two horizontal bands to the prolapsed mucous membrane of the rectum, in such a degree as to cause moderate but not too deep sloughing, these bands, on healing, will leave cicatrices which by their contraction are often sufficient to cure the complaint. In children, in whom prolapsus ani is rather common, benefit is often obtained from bathing the part with a weak nitric acid lotion, and giving the same acid internally.

Condylomata on the limbs or genitals, especially when of a syphilitic origin, disappear under the external use of nitric acid.

Warts and Corns.—Erasmus Wilson recommends nitric acid for the treatment of callosities, the cauterized portion being removed occasionally by the knife. I have used nitric acid extensively for the removal of moles on the face; the cicatrices are hardly visible.

Nævi.—Superficial nævi may be safely destroyed by painting with strong nitric acid; Mr. T. Holmes speaks highly of this method. Due precaution should be taken to protect the sound skin, and an alkaline lotion should be used afterward. If the affected part be extensive, a portion only should be treated at one time, the caustic being applied about every second day, until its full effect be produced (*Lancet*, ii., 1866, and 1867). For small nævi on the face, I can recommend puncture with a needle dipped in the acid: it is safe, effective, and leaves comparatively little scar.

Indolent Ulcers.—For ordinary indolent or moderately sloughing ulceration, a lotion containing nitric acid diluted, about 1 dr. in ½ pint of water, is a good dressing.

Pruritus.—A similar lotion will often relieve itching in papular and neurotic diseases, such as lichen and prurigo; it may be conjoined with prussic acid, or with the liquor carbonis detergens.

Alopecia.—The acid, diluted with so much olive oil as will prevent the caustic though not the stimulant effects, makes a good liniment in some cases of falling off of the hair from debility.

THERAPEUTICAL ACTION (INTERNAL).—*Dyspepsia—Debility.*—Dilute nitric acid is a serviceable tonic in cases of nerve-debility and of convalescence from acute disease, when appetite and digestive power are impaired. It acts well in combination with a few minims of tincture of nux vomica, stimulating the gastric glands and the biliary secretions, and may be given between meals, or shortly before or after, according to the conditions already mentioned under hydrochloric acid (*v.* p. 197).

Hepatic Disorder.—Nitric acid has long been held in repute for the treatment of chronic hepatic congestion, or chronic hepatitis, especially when occurring in Anglo-Indians, and after mercurials have been used. Dr. Murchison met with marked improvement, even in cases of *waxy liver*, from the continued use of nitric acid with vegetable bitters ("Diseases of Liver," 1868, p. 33), but in later writings he remarks that there is no evidence of its assisting bile-flow, and that its action is less direct than that of alkalies; that in congestion (of acute character), or when lithiasis is present, it either does no good, or aggravates the malady, though it may relieve the dyspepsia of debility: he sometimes gives alkalies before a meal, and acid after (*British Medical Journal*, i., 1874). R. Martin, Thudichum, and indeed the majority of writers twenty years ago, allowed to nitric acid a larger sphere of usefulness in hepatic disorder, jaundice, etc.; it was presumed to "lixiviate biliary deposits, tone digestion, and act antiseptically" (*British Medical Journal*, ii., 1860). Annesley noted that it acted better, the more freely it was diluted—he used it in chronic splenic disorder. I have found nitric acid useful in chronic hepatitis, when watery diarrhœa and constipation occur alternately.

Phosphatic Urine—Chronic Cystitis.—Sir B. Brodie constantly employed strong nitric acid, in full doses—30 min. or more—largely diluted, and given in divided doses during the day, for phosphatic and alkaline urine. In cases of chronic cystitis, and even of phosphatic calculus, he also employed local injections containing 1 to 2 min. of the strong acid in the ounce of warm water. The best mode of administering nitric acid under these conditions is to give 5 to 10 min. of the dilute acid in 1 or 2 oz. of decoction of pareira brava every three or four hours.

Diarrhœa.—When the dejections are frequent, serous or "watery" in character, especially if markedly alkaline, and if there be no evidence of acute inflammation and not much pain, then nitric acid acts well, and in cases of profuse purging from summer heat, and in the diarrhœa of phthisis, it has a deserved repute: if necessary, it may be combined with a small quantity of opium. In dysenteric diarrhœa with tenesmus, blood, and profuse discharge of mucus, nitric acid acts well. Dr. Hope had reason to prefer the dilute *nitrous* to the nitric acid; he gave 15-min. doses, with laudanum and camphor water, in most forms of diarrhœa and chronic dysentery, with much success. Dr. H. C. Wood found it succeed

in some cases where nitric acid had failed: it is, however, unstable, and requires to be recently prepared.

Constipation.—Dr. Graves says, "In constipated habits I have occasionally derived very remarkable benefit from the use of nitric acid given in sufficient doses. It seems, like the carbonate of iron, to possess the advantage of combining tonic with aperient qualities" ("Clinical Medicine," ii., p. 215). I think that this different action of the medicine depends upon dose, and perhaps combination, and is not contradictory to that mentioned in the last section. Nitric acid in *small* or moderate doses is astringent, especially if prescribed with opium; but nitric acid in *full* doses has an aperient effect, especially in combination with bitter infusion, such as gentian; this may be traced either to direct intestinal irritation or to hepatic stimulation.

Otorrhœa occurring in scrofulous children or in syphilitic patients, is often quickly controlled by a course of this acid.

Purulent Ophthalmia, with extensive ulceration of the cornea, whether of a gonorrhœal or scrofulous form, is much benefited by a course of 5 to 10 min. of the dilute acid three or four times a day, together with local treatment.

Fevers.—Dr. Osborne has recorded a good experience of nitric acid in typhoid fever (*Lancet*, ii., 1862), and Dr. Bailey (U. S.) in intermittents—he prescribed it to relieve profuse sweating, and unexpectedly found a curative effect on the ague: of ninety cases, eighty made a rapid recovery. Dr. Hammond has corroborated his results (Ranking, 1862).

Secondary Syphilis.—A course of dilute nitric acid will often be of service in later syphilitic cachexia, especially after mercurials have been used, and in debilitated subjects. It benefits ulcerations of the mouth, throat, and nose, and also periosteal swellings, and may be applied at the same time in the form of bath—1 to 2 oz. for each bath. Mercurial salivation is relieved by the acid.

Skin Diseases.—In chronic syphilitic cutaneous eruption, such as rupia or psoriasis, this acid has been rightly commended. In ordinary, non-specific disorder, it is indicated whenever general debility is a marked symptom, and especially when nerve-power is impaired. Dr. Tilbury Fox frequently gave it, in conjunction with a bitter tonic, for psoriasis in weakly subjects.

Chronic Laryngeal Congestion.—In this malady, when brought on by excessive vocal exertion, as in singers and readers, 5 to 6-min. doses of dilute nitric acid in sugared water have been found very useful, bracing up the relaxed membrane and throat follicles, and relieving hoarseness; also in chronic laryngitis, dependent upon a syphilitic taint, it is of much use.

Chronic Bronchitis.—I agree with some good observations made by Dr. Glover, drawing attention to the benefit obtained sometimes from

nitric acid in cases of chronic catarrh and bronchitis when secretion is fairly free, when nerve-exhaustion is a prominent symptom, and when ammonia and expectorants fail to relieve (*Lancet*, i., 1865); this fact deserves more attention than it has yet received. Dr. Glover combines nitrous ether with the acid, and sometimes tinct. camph. co. is also indicated, the precipitated camphor, etc., being readily suspended in cetraria or mucilage.

Pertussis.—Nitric acid has been found by some observers valuable in relieving the spasmodic recurrent attacks of cough, and lessening profuse expectoration; and it may certainly be credited with tonic bracing action on the faucial and laryngeal membranes. Arnoldi, who introduced this mode of treatment, ordered as much acid as would render a tumblerful of sugared water "like lemon juice," to be taken every three or four hours. Dr. Gibb, who reported the best results, gave as much as 10 min. to infants, and 40 min. to children of ten years; and some other practitioners have used this medicine with success, as Ussher (*Medical Times*, i., 1862), and Berry—in an epidemic at Lancaster—who found it effective, safe, and cheap (*Medical Times*, i., 1873). I have been reluctant to press it for fear of injuring teeth, and when I have used it as freely as could be borne, I have not seen definite benefit.

Preparations and Dose.—*Acidum nitricum—Aqua fortis:* dose 1 to 3 min. freely diluted. *Acidum nitricum dilutum:* dose, 10 to 30 min. freely diluted.

[Preparations, U.S.P.—*Acidum nitricum*, sp. gr. 1.420, *Acidum nitricum dilutum: nitric acid* 3 troyounces, water sufficient to make 1 pint.]

Adulterations.—Chiefly sulphuric and hydrochloric acids.

ACIDUM PHOSPHORICUM DILUTUM—DILUTE PHOSPHORIC ACID, H_3PO_4=98.

This acid is rather widely diffused, being found free or combined with alkaline and earthy bases in soils, and in many vegetables and fruits, such as wheat, potatoes, rice, lemons, etc., also in fish, and in the bones, nerves, and flesh of animals, and according to Marcet, more in the lungs than in other parts; also in the urine and other secretions.

Preparation.—The officinal (tribasic) acid is prepared by distilling phosphorus with dilute nitric acid by the aid of gentle heat; some of the latter acid passes over in vapor, and therefore the distillate is returned to the retort occasionally in order to prevent loss: it is finally concentrated to a syrupy consistence (heat being used to get rid of nitrous fumes), and the resulting strong phosphoric acid is diluted with water to a sp. gr. of 1.08, which represents about 14 per cent. of acid.

Characters and Tests.—Tribasic or orthophosphorous acid is a colorless, inodorous liquid, of acid, not unpleasant taste, and even when concentrated, not corrosive, nor coagulating albumen. It gives with ammonio-nitrate of silver, a canary-yellow precipitate of phosphate.

There are two other forms of phosphoric acid, not officinal, but of much interest to the chemist. If heat be applied to the common acid it loses water, and its first anhydride (pyrophosphoric or bibasic acid, $H_4P_2O_7$) is produced: by a higher heat, more water is driven off, and its second anhydride, glacial or metaphosphoric or monobasic acid HPO_3, is formed. This is in the U. S. Pharmacopœia, and is a colorless, ice-like, deliquescent solid: it is the only form which coagulates albumen.

All soluble phosphates give a white crystalline precipitate with sulphate of magnesia, after the addition of sal-ammoniac and liquor ammoniæ (ammonio-magnesian phosphate, or "triple phosphate"—$MgNH_4PO_4$).

Absorption and Elimination.—Phosphoric acid is readily absorbed by the stomach. Ordinary doses combine with alkalies—potash or soda salts—probably displacing them from combination with weaker acids, lactic or carbonic, and forming phosphates; after larger or poisonous doses, Hoffmann states that he has found it free in the blood or loosely combined with albumen (*Journal de Chemie*, June, 1868).

As phosphate it is mainly eliminated in the urine, and Böcker found the excretion of potash phosphate especially increased under its use: some acid may possibly be eliminated in a free state.

Physiological Action.—The action of phosphoric acid bears a general resemblance to that of sulphuric acid, but in medicinal doses it is less liable to irritate the stomach or interfere with digestion, and it exerts a more stimulating effect on the general system: it has a more pleasant taste than the other inorganic acids. The pharmacopœial solution does not coagulate albuminous tissues, and like oxalic and tartaric acid only coagulates egg-albumen after addition of chloride of sodium or other neutral salt.

Circulatory System.—The effect of moderate doses of phosphoric acid is stimulant, but of large doses, especially when injected into the blood-current, depressant. Two cub. centim. of a four per cent. solution given to a frog, increased the pulse-frequency, and the direct application of acid to the frog's heart at first strengthened though it afterward weakened the contractions; after death, the heart-muscle was non-excitable (Munk and Leyden). In warm-blooded animals, after the subcutaneous injection of about 8 grammes, slowness, weakness, and irregularity of heart-beat occurred, with retarded respiration, lowered temperature, prostration, and death (Meyer).

After injections of phosphoric acid into the jugular vein, the blood-pressure and the pulse-frequency are lowered, although after small quantities they quickly rise again. Pavy found that he could inject 8 or 10

dr. of the pharmacopœial solution into the jugular of a dog without causing death, and if, in any animal, the maximum amount compatible with life was injected, the urine and the arterial blood became highly charged with sugar ("Guy's Hospital Reports," vol. vii., 1861). We may connect this result with the fact that phosphoric acid acts even more powerfully than hydrochloric in diminishing the alkalinity of blood (Walter), while, on the other hand, injections of soda prevent the production of artificial diabetes; but the full bearing of such facts is not yet known. Injections of acid into the carotid caused primary slowing of pulse with secondary quickening before death, strong inspiratory cramp, convulsions and coma (quoted by Husemann). After death from excessive quantities, ecchymoses were almost always found in the lungs, and the blood was altered, being dark but fluid, and not easily coagulable, sometimes gelatinous. The effect on the blood is not always the same: thus, Pavy in one experiment found the "large venous trunks in the liver plugged with coagulated blood" after an injection of 30 dr. of acid into the duodenum; and Gubler says, "introduced into the veins of animals, phosphoric acid coagulates the blood and causes death in a few minutes:" this depends on the dose and concentration. Neumann states that the corpuscles are not destroyed by the acid, but may be much altered in form and vital properties.

The action upon man is of more practical interest, but very few investigations have been made with phosphoric acid. Bobrick records a rise of the pulse from 70 to 90 beats per minute, but in the course of an hour it fell to 66; this was after a dose of ½ oz. A rigor also occurred, the cause of which is not easy to trace, but it was followed by a pleasant sensation of warmth. Dr. J. B. Andrews (N. Y.) administered doses of from 1 to 3 dr., and investigated the effect by means of sphygmograms taken at intervals of from fifteen minutes to one hour. He says, "Within the first interval there is an increase in the force of the pulsations, though there is little change in the number during the whole time of experimentation. The increase is most marked after the lapse of from one to two hours, and it is not till after several hours that the pulse returns to its normal condition. The first experiment I made upon myself, beginning with 20 drops, and continuing the use of the remedy in increased doses till the amount of 4 dr. was reached. The sensations experienced from 40 min. to 3 dr. were those of moderate alcoholic stimulation, slight pain through the frontal region, and a buoyancy and lightness of feeling rather agreeable. . . . In the pulse-traces, additional force is manifest in the heart's action in all cases, and in the general appearance of weakly persons placed on acid treatment the same fact is apparent—the congestion of the extremities and lips has soon given place to a more natural color" (*American Journal of Insanity*, October, 1869).

Nervous System.—Dr. J. B. Andrews and many others find phosphoric

acid to be a powerful nerve-tonic, but the conclusions are founded more upon clinical observations on depressed persons than on the healthy. "Moderate doses produced on the latter the feeling of buoyancy and exhilaration already mentioned, but larger quantities caused a feeling of drowsiness, an inclination to lie down, and unwillingness for mental labor." The acid exerts also a marked control over the vaso-motor nerves, and through them improves the tone of the circulation. Hecker and Burdach concluded that phosphoric acid acts more than any other on the nervous system, heightening excitability in a great degree. Sundelin asserted that this action is directed especially to the genital organs, and although neither Neligan nor Andrews could verify this, I have myself noted it in sixteen patients, who had no knowledge of the supposed aphrodisiac quality of the drug; they all complained to me of such effects in greater or less degree.

Digestive System.—Moderate doses tend to improve the tone and functional power of the stomach, and, as already remarked, this acid irritates much less, even after continued use, than the other inorganic acids; large or concentrated doses, however, taken by the mouth, may cause gastro-enteritis, and after death, redness, erosion, and ecchymoses have been found in the stomach and duodenum (Monk and Leyden). When Pavy injected 1 to 2 oz. into the stomach of dogs it was quickly rejected, but on passing it into the duodenum, a saccharine condition of the urine and the blood was produced, just as after intravenous injections. After toxic doses, fatty degeneration has been found in the liver, kidneys, and muscular tissue.

Synergists and Antagonists.—The same as for other mineral acids (*v.* p. 196).

Therapeutical Action (Internal).—*Nerve-Debility.*—The therapeutical influence of phosphoric acid is mainly exerted on the nervous system, and in the treatment of nerve-debility acts much like iron in anæmia, as a chemical food supplying something actually deficient in nerve-nutrition. When mental effort has been protracted till a sense of weariness renders its continuance difficult, a dose of the acid, from its stimulant effect, relieves fatigue, and seems to invigorate the mental powers, and prepare the mind for renewed exertion.

Dr. J. Andrews, describing a case of impaired mental power from excessive brain-activity, observes, "The patient is languid, unable to do mental work with the usual facility, nervous, and at times fearful, timid, and agitated, the memory weakened, and permanent impairment threatened. Such cases have been termed 'cerebral paresis,' but for their recovery, relaxation from business, and phosphoric acid, with some suitable tonic, generally suffices."

Of more serious conditions, such as dementia following acute mania, Dr. Andrews remarks, "This is a period of nervous exhaustion, of reac-

tion from the increased mental and physical activity which marked the previous state of the disease; tone and vigor must be supplied to the prostrated system, and for this phosphoric acid is of material service." It relieves peripheral congestions connected with impaired tone of vaso-motor nerves, and in weakened relaxed conditions akin to impotence, and resulting from sexual excess, it has proved a special help.

Fever.—In any fever where the nervous system is specially depressed, phosphoric acid is indicated; it assuages thirst, and helps to remove exhaustion; its pleasant taste is one advantage over the other mineral acids.

Stromeyer, and others, recommend it in "eruptive fevers." The following is a convenient form:—℞. Acidi phosphorici diluti, fl. ʒ iij.; glycerini, fl. ℥ j.; decocti hordei, Oij.: mix, and use when cold as a common drink.

Diabetes.—Phosphoric acid often relieves the thirst of this malady, and has been recommended by Latham, Paris, Watson, and other practical physicians; on the other hand, the experiments of Pavy (already quoted) indicate that much of it would be injurious, and Griesinger not only states that it does not lessen the excretion of sugar, but in one case supposes it actually to have caused the malady.

Against this, we might set a case recorded by Thornley, in which the thirst was relieved and the patient apparently cured (*Medical Press*, May 20, 1868); but, without being in a position to dogmatize on the matter, I may say that I have known the acid on several occasions to relieve symptoms and diminish the amount of sugar in the urine.

Urinary Disorder.—In phosphatic deposits connected with waste of nervous tissue, and in alkalinity of urine with nerve-depression, phosphoric acid is very useful, and it has relieved the symptoms of phosphatic calculus and urethro-vesical catarrh, when nitric and hydrochloric acids had failed. Benefit has also been derived from it in *oxaluria.*

In *Rachitis*, the milky phosphatic condition of urine is cleared by the acid, though Dr. H. Wood considers that the phosphates act better.

Phthisis—Struma.—In these conditions generally, phosphoric acid fulfils many indications as a grateful moderately astringent tonic; it relieves hoarseness and dry irritating cough accompanied by pain and laryngeal soreness. Dr. Cotton gave it to twenty-five patients with chronic uncomplicated phthisis at Brompton Hospital, and observed benefit in a few advanced cases: it improved appetite and controlled secretion, although sometimes nausea and pain were excited: he could not trace a specific effect from it, but rather the action of a general nerve-tonic; it acted specially well combined with iron (*Medical Times*, i., 1863). Dr. C. J. B. Williams recommends it with cod-liver oil (*Lancet*, ii., 1868, p. 213).

In the *dyspepsia* so common in phthisis, it is also useful, relieving the

pain, sickness, and diarrhœa which occur after meals. Profuse night-sweats and other exhausting discharges are controlled by it, and it exerts a sedative effect upon the excessive sexual desire which often developes in some stages of phthisis. Dr. Todd used it in cardialgia.

Hæmoptysis—Hemorrhage.—M. Hoffman has written to specially recommend this acid in hæmoptysis; and the main reasons for his preference of it would seem to be its "less corrosive action," and better toleration by the stomach, otherwise its stimulant powers would make it less generally suitable than sulphuric acid; he gives 10 to 30 drops in mucilage (*Journal de Chim. Médic.*, June, 1868). I have myself seen good results from the acid in purpura and passive hemorrhage, also in metrorrhagia.

Strumous Conjunctivitis.—This malady is often troublesome, not so much from its severity, as from its persistence and great tendency to relapse, and Mr. Balman, has written to praise phosphoric acid, not only in struma, but especially "in the intermittent ophthalmia of a scrofulous constitution": he says that, given in doses of from 5 to 20 min. in calumba, the acid both cures and prevents recurrence of the affection (*London Medical Gazette*, August 22, 1858).

Scorbutus.—Liebig and others have held that the scurvy of sailors is mainly owing to the exclusion of phosphoric acid from their diet, since in the ordinary preparation of meat for sea-stores the greater portion of the acid is extracted from it, and the complaint has been cured by giving food containing the acid, although the sailors continued to use the salted beef to which scurvy was attributed ("Letters on Chemistry," p. 425). Professor Galloway has verified the presence of phosphoric acid in lemon-juice, and hence, according to Morgan and Neligan, its superiority to citric or tartaric acids, but I am not aware that the theory has been largely tested in practice.

Bone Diseases—Caries.—In caries, M. Leutin applied dilute phosphoric acid to the affected bone with the idea of supplying a deficient element, and practically this sometimes relieves and improves the bone-condition. Its good effect is, however, better seen from internal administration, especially if much hectic be present. It is said to be also beneficial in cases of unusual depositions of phosphate of lime, as in exostosis, and bony tumors generally (Neligan, Garrod). Wormald states that the detection of phosphoric acid in pus is diagnostic of necrosis (*Lancet*, ii., 1862, p. 440).

In *Rachitis* I have found it a useful medicine, and it relieves the diarrhœa and sweating of that disorder.

Diarrhœa.—Phosphoric acid is suitable for cases of diarrhœa when an acid is indicated. Sedgwick strongly recommends it for choleraic cases, and argues for its use in true cholera (*Lancet*, ii., 1871, p. 280).

PREPARATION AND DOSE.—*Acidum phosphoricum dilutum:* dose, 10 to 30 min. freely diluted.

[PREPARATIONS, U. S. P.—*Acidum phosphoricum dilutum*, sp. gr. 1.056. *Acidum phosphoricum glaciale*—used in preparations.]

ACIDUM SULPHURICUM—SULPHURIC ACID—OIL OF VITRIOL, H_2SO_4,=98.

This occurs native in the water near volcanoes, as in Java, and in the "Sour Springs," in the town of Byron, Genesee County, N. Y. It is found in combination in twenty-two natural sulphates, also with ammonium in rain-water, near towns. It contains 79 per cent. of anhydrous sulphuric acid, SO_3.

There are two other forms of the same acid, the *acidum sulphuricum dilutum*, and the *acidum sulphuricum aromaticum*, which are weaker by one-seventh than the first-mentioned.

PREPARATION.—By passing sulphurous acid gas (sulphurous anhydride) into leaden chambers, and bringing it there into contact with steam and nitrous fumes (nitrous anhydride); from the latter it absorbs an atom of oxygen, becoming sulphuric acid (anhydrous), and this combines with water to form a dilute sulphuric acid, which is afterward concentrated up to a sp. gr. of 1.843; a small quantity of nitric oxide gas will act as a carrier of oxygen from the atmosphere to a large quantity of sulphurous acid. In chemical formulæ the main reaction may be represented as follows:—

$$SO_2+H_2O+N_2O_3=H_2SO_4+2NO.$$

CHARACTERS AND TESTS.—The pure acid is an oily-looking, colorless liquid, but the commercial acid is often dark-colored from contained fragments of organic matter, which are charred by the acid. It has an energetic affinity for water, which it absorbs readily, so that a partially-filled bottle of acid, if exposed to the air, will, after a time, overflow; if quickly mixed with water it undergoes condensation, and much heat is evolved. A very small quantity of sulphuric acid, or of any soluble sulphate, can be detected by adding to the diluted solution a little chloride of barium, which gives a dense white precipitate, insoluble in acids.

ABSORPTION AND ELIMINATION.—Moderate doses of the dilute acid are readily absorbed, either as sulph-albuminates (Orfila), or, after combining with bases in the gastric secretion, as sulphate of potash or soda (Miguel): very small doses only in the latter form (Husemann).

The dilute acid forms with albumen both a soluble, and an insoluble compound according to the degree of dilution—the former resulting from quite weak acid (Berzelius). That dilute sulphuric acid may be absorbed through the *skin*, follows from the experiments of Lebküchner, who in-

duced acid reaction of urine and fæces by applications to the abdomen of rabbits.

Gubler teaches that this, like the other mineral acids, circulates in the blood, but loosely combined with albumen, and that on reaching the emunctories the combination breaks up, albumen remaining in the vessels, while the acid passes out with the excretions, combining with the bases therein found.

It has been a question whether after poisonous doses, the acid may be absorbed and remain free in the blood, leading to its coagulation. Geoghegan states that after 1½ oz., when a woman survived thirty-one hours, he found traces of acid in the pericardium and in the kidney, not in the blood, but in that fluid he found much *phosphoric* acid, derived, he suggested, from phosphate of soda from which sulphuric acid had displaced it (*Medical Gazette*, xl.). In another case Dr. Walker found a trace in the cerebral fluid and in the cardiac blood (*Edinburgh Journal*, 1850). Casper found the blood and serous fluids acid, and Carus states that he found sulphuric acid in all the organs of a fœtus, after a fatal dose taken by the mother ("Beck's Jurisprudence," ii., p. 429). More recent researches state that mineral acids cannot be detected free in the blood, and that its reaction cannot be rendered acid consistently with life (F. Walter; *v.* Hydrochloric Acid). It is not likely that the coagula described by Bouchardat in the great vessels were really due to direct action of free acid,—Taylor could find no trace of it in similar coagula ("On Poisons," p. 31).

The acid is *eliminated* by the urine, and according to Dr. Letheby, very quickly after full doses (*Medical Gazette*, xxxix., p. 116). Most observers agree that it cannot be found free in that secretion, but as sulphate (Bence Jones), and the heightened acidity is really due to uric and lactic acids displaced by the stronger sulphuric acid from their ordinary combinations. Seeing the comparatively small amount of sulphuric acid accounted for in the renal secretion, Headland suggested that some passed by the lower bowel and the skin, and this is probable.

Physiological Action (External).—The dilute acid, applied to the skin, causes some burning pain and pallor, followed by redness; more concentrated, it destroys the epithelium, changing it into a firm brown mass. It coagulates albumen, and disintegrates horny tissues with formation of leucin and tyrosin. In its full strength, it causes destruction and sloughing of any tissue by virtue of its strong affinity for organic bases, as well as for the water with which they are combined. The acid has disinfectant and antiseptic powers, and destroys infusorial life.

Physiological Action (Internal).—*Digestive System.*—Very small doses give a characteristic markedly acid taste, and lessen the sensation of thirst; 10 to 15 min. of the dilute acid, administered several times at intervals, stimulate the appetite and exert some astringent effect on the

gastric and other secretions. If continued, however, the medicine induces dyspepsia with acid eructation; colic, and even diarrhœa, which may be due to the large amount of alkaline sulphates formed, as well as to direct irritation.

The local symptoms induced by *toxic* doses of the strong acid are very severe; intensely acid pungent taste is followed by acute burning pain in the mouth, pharynx, and stomach, and violent retching and vomiting, the ejecta usually containing dark blood; there is extreme thirst and great sense of distress—sometimes purging with tenesmus. The faucial inflammation may induce suffocation, angina, or laryngeal œdema, and thus prove fatal early in the case, or peritonitis may be set up, and if death do not occur from collapse, it may follow on perforation of the œsophagus, stomach, or bowel in twelve to forty-eight hours after the poisonous dose; should life be saved for the time, the inflammation of the alimentary-tract is likely to be followed by serious contraction, etc.—swellings, and suppuration of the parotid glands may occur. Any slough produced by this acid is black in color.

Circulatory System.—Bobrick found, with frogs, that this acid, given by the stomach, or applied to the skin, caused the heart to act more slowly, and finally stopped it in diastole. Hertwig, experimenting on mammalia, found that moderate doses of the dilute acid lowered the pulse-rate and the temperature, while arterial tension was increased. I am not aware that similar results have been verified on the healthy human subject, nor has proof been given of the acid's power to lower temperature in febrile conditions. It has been said by some that the blood becomes less, by others more, coagulable, but its exact state is not ascertained; nor do we rightly know whether the smaller vessels are contracted or not by the acid (Nothnagel; *v.* p. 228). When injected into the veins it causes instant death from coagulation of blood and thrombosis, and the corpuscles are altered or destroyed by toxic doses taken internally.

In cases of poisoning by the acid, the disturbance of circulation is mainly secondary to the gastric irritation: there may be faintings, passing on to actual syncope or collapse, the pulse becoming later rapid and small, the extremities icy cold, and respiration labored and superficial.

Nervous System.—Ordinary doses do not produce other than tonic effects upon this system. In fatal cases of poisoning, the mind is generally clear or but slightly clouded; exceptionally, coma has developed.

Glandular System.—Most of the secretions become more acid under the free use of this drug, and some of them, especially those of the skin and the bowel, are lessened in amount. Bobrick, however, found the quantity of urine and the amount of urinary sulphates increased by it. After large doses, Leyden and Munk distinguished different conditions corresponding to different alterations in the kidney; finding albumen

alone, or with epithelial casts, or with fatty globules and epithelium, or in addition, hyaline casts, and blood- and pus-corpuscles.

Pathological Changes.—The anatomical lesions found in the stomach after death vary according to the concentration of the acid, and the duration of its effects. In milder cases, the epithelial and the upper layer of the rete mucosum are shrunk, parchment-like and greyish: in the severest, the whole tissue is mortified, blackened, and changed into a soft gangrenous mass. Fatty degeneration of different organs has also been lately described as a constant result of poisoning by sulphuric acid, and particularly in the liver, the striped muscular tissue, the heart, and the renal epithelium. This change is to some extent explained by the destructive action on the red corpuscles, which are in part destroyed, and in part altered, becoming smaller, darker, and of granular appearance, and certainly unequal to their proper function; hence the tissues are imperfectly nourished, and readily degenerate. The same alteration in the oxygen-carriers explains the lowered temperature, the feeble pulse, and the general debility, as well as the functional albuminuria from excretion of constituents of the altered blood-cells.

Synergists.—The other acids and cooling remedies are allied in action, and, as regards styptic effects, ergot and astringents generally are auxiliaries.

Antagonists—Incompatibles.—Warm stimulating remedies and "fluidifying" medicines, such as mercury and iodides, antagonize some of the effects of sulphuric acid. Alkalies and bases are chemically incompatible. The best antidotes in a case of poisoning are magnesia, chalk or white-wash, and soap, which should be given in albuminous solutions, such as milk and water. Alkaline carbonates are considered not advisable because they form irritant compounds (Christison); also they evolve much carbonic acid, but may be used in cases of emergency. Oil to protect the mucous membrane of the stomach is also very useful.

Therapeutical Action (External).—The highly caustic property of strong sulphuric acid is utilized comparatively seldom on account of the difficulty of restraining it within due limits.

Chancre—Gangrene—Cancer.—In chancre, with phagedænic ulceration, Ricord recommends a caustic paste made with sulphuric acid and charcoal to be applied on linen for several hours—until a slough forms. In hospital gangrene the pure acid has been successfully employed (*Medical Times*, i., 1859). For such purposes and for cancer, Sir J. Simpson mixed it with zinc sulphate. The reason for using powders, especially charcoal, to mix with the acid, is to secure a full strength in convenient form without dilution with water: Syme employed sawdust; Velpeau, saffron.

Caries—Necrosis.—It is evident that a lotion containing mineral acid will dissolve out the earthy bases of bone-tissue and quicken disintegra-

tion, and for this purpose it has been applied to some extent in surgery. Chassaignac recommended dilute hydrochloric acid, but more recently Mr. Pollock has brought forward much evidence in favor of the application of sulphuric acid mixed with an equal part of water, "for the more speedy removal of dying bone, or more rapid separation of dead portions, or destruction of the surface of carious cavities;" he finds it simple and safe, and comparatively painless—nor has he ever seen bad consequences from it. His first case, one of necrosis of cranial bone, was touched daily with the dilute acid,—the diseased part quickly separated, and healthy granulations formed. Cavities may be filled with lint soaked in acid, and, when this is removed, in two or three days an opaque white layer may be seen and taken away; this is a slough, soft owing to removal of earthy particles, which may be found lying loose in the wound: any pain caused by the caustic ceases in a short time because the acid is soon neutralized. In some flat bones, such as those of the trunk or pelvis, the undiluted acid may be cautiously used. Recovery may be secured "in weeks instead of months" under such treatment, though it will not always succeed without operative interference (*Lancet*, i., 1870). W. Hayward, H. Marsh, and others, have also recorded good results from the practice recommended by Mr. Pollock.

Ectropion—Entropion.—In these deformities of the eyelids, sulphuric acid has been used by Laurence to cause a linear cicatrix, which, by its contraction, shall restore the natural position of parts, but other methods of cure are preferable.

Poisoned Wounds.—This, like the other mineral acids, when employed to cauterize poisoned wounds, bites, etc., has the advantage over solid caustic of more penetrating power. W. Frazer considered strong sulphuric acid better than any other ("Materia Medica," p. 12).

Parasitic Skin Diseases.—In ringworm and in scabies, an ointment containing 1 dr. of acid to the oz. of lard has sometimes proved useful, though irritating; for the latter malady it is said to be largely used in the Prussian army (Neligan).

Pruritus.—In prurigo, lichen, and chronic urticaria, disorders attended with violent itching, a lotion containing 1 to 3 dr. of dilute acid in 8 oz. of water often relieves. Pereira says that its internal administration is also efficacious.

Angina. For relaxed surfaces coated with tenacious mucus dilute sulphuric acid is an excellent cleansing astringent: hence it is in constant use as a *gargle* (1 to 2 dr. in 8 oz. of infusion of roses) for relaxed uvula, etc.; in weaker proportion it is also suitable for scarlatinal throat. The addition of 2 dr. of alum to the gargle often greatly increases its value.

Therapeutical Action (Internal).—It is commonly said that for digestive disorders requiring an acid, hydrochloric is the best: to stimulate hepatic and intestinal secretion nitric acid is indicated, while the as-

tringent effect of sulphuric is of special value in controlling sanguineous and other discharges.

Hemorrhage.—Sulphuric acid was formerly in very frequent use as an internal remedy for hemorrhage, especially of passive character, whether from the stomach, lungs, or uterus. That there is difficulty in explaining how it can exercise astringent effect after dilution and possibly combination in the blood, would be no argument against its use if this were *proved* efficacious; but my experience is the same as that of many modern observers (among whom I may mention Nothnagel and H. C. Wood), who give to sulphuric acid a *secondary* place among hæmostatics, although I have known it succeed *sometimes* when other remedies have failed.

Diarrhœa.—Dilute sulphuric acid has a well-deserved reputation in various forms of intestinal flux, and especially in summer diarrhœa of choleraic character: it often answers well, but when given alone I have sometimes found it aggravate the disorder, whether by irritation or by increasing the acidity of secretions: the aromatic sulphuric acid should then be preferred in combination with some preparation of opium.

In diarrhœa, with coated tongue and evidence of biliary disorder, the acid has acted admirably with small doses of magnes. sulph., tinct. rhei., and aqua chloroformi: it is a good remedy for children.

Cholera.—Dr. Curtin has recorded that a severe epidemic in an institution under his direction ceased within twelve hours after the inmates were treated freely with "sulphuric acid lemonade"—the only fresh case occurring in a man who refused to take the medicine. Two days after it was discontinued two new cases appeared, and an epidemic threatened, but was again stayed by the acid, and in the surgical wards, where the acid was used from the first, no case appeared, while every other part of the institution suffered more or less (*Philadelphia Medical Times*, iii., p. 649). This experience makes it desirable under similar circumstances to adopt the same method as prophylactic.

Fever.—In the diarrhœa of enteric fever, H. Kennedy, Murchison, and other authorities advocate the use of sulphuric acid (*v.* p. 197). We do not expect from it, as formerly, a power of shortening the morbid process; but it will allay thirst, and, to some extent, moderate the pyrexia and the undue secretion. In any enteric cases, the dose used should be small and well diluted: the aromatic, I find preferable to the simple form.

Pyrexia—Phthisis.—Whether sulphuric acid does or does not lower pulse and temperature in the usually employed doses, it certainly is of more service in secondary pyrexial states than in specific fever. In subacute inflammatory conditions of protracted character occurring, *e.g.*, during caseous pneumonia or chronic phthisis, it alleviates the general symptoms, and sometimes the local conditions. It is well suited for phthisical cases with a tendency to undue discharges, for it acts as a grateful tonic and astringent, lessening the night-perspirations, the intestinal flux, the

expectoration, and passive hæmoptysis; by combination with opium, or belladonna, aromatics, etc., so much relief may be sometimes given as to merit for the remedy its old title of "Elixir Vitriol."

The presence of cough does not contra-indicate its use, but irritation of the fauces must be obviated by mucilage or syrup: acids should, however, be omitted if gastric irritation be excited by them.

Palpitation.—Nothnagel recommends this acid, combined with laxatives, in the palpitation of plethoric subjects; it is not indicated for the anæmic or chlorotic, nor specially useful in the palpitation of valve disease.

Lead Poisoning.—Since the publication of the cases of M. Gendrin and Dr. H. Bennett in 1846, the acid has had more or less reputation as an antidote and prophylactic in poisoning by lead; but modern observation does not quite corroborate their estimate of it. Tanquerel especially failed to obtain any good results ("Maladies de Plomb," ii., p. 497); on the contrary, the use of an acid lemonade seemed to make the workmen rather more liable to colic.

Preparations and Dose.—*Acidum sulphuricum—Oil of vitriol:* is not used internally except in the following:—*Acidum sulphuricum aromaticum:* dose, 5 to 30 min. freely diluted. *Acidum sulphuricum dilutum:* dose, 5 to 30 min. freely diluted. An alkaline mouth-wash should be used after taking the acid, or a little butter placed on the teeth before.

Adulterations.—The usual impurities of this acid are salts, nitrous oxides, arsenic, and lead.

ACIDUM SULPHUROSUM—SULPHUROUS ACID, SO_2, = 64.

The pharmacopœial sulphurous acid is a solution of the gas in water, containing 9.2 per cent. by weight=twenty times its volume.

Preparation.—By deoxidizing sulphuric acid by distilling it with coarsely-powdered wood charcoal. The carbon combines with part of the oxygen of the acid to form carbonic acid and probably carbonic oxide, while sulphurous acid gas (anhydrous) passes over into a receiver containing distilled water, being previously washed from sulphuric acid and other impurities.

$$2C+H_2SO_4=CO_2+2H_2O+2SO_2$$

Characters and Tests.—A nearly saturated solution of sulphurous anhydride, SO_2, colorless, of strong suffocating odor and pungent acid taste, which, however, is not unpleasant in moderate dilution. It bleaches vegetable colors, and is an energetic oxidizing agent: it is said to absorb radiant heat in a high degree (R. Bird). The hydrated acid can be obtained in crystals but is very unstable. A solution of the officinal

strength and upward oxidizes on exposure to light and air (*e.g.*, when kept in partially-filled transparent bottles), with formation of sulphuric acid—an important change, since the special properties of the drug are thereby impaired or lost; contact with chlorine at once induces this change. It should therefore be carefully kept; or better still, be freshly prepared when wanted. Water would absorb forty or fifty times its bulk, alcohol still more; but Professor Redwood recommends a 5 per cent. solution, as more easily made and more stable than that of the *British Pharmacopœia.*

Tests.—1. When evaporated, it should leave no residue. 2. Barium chloride gives a copious white precipitate (of barium sulphate) if sulphuric acid be present. 3. Sulphurous acid decolorises a solution of iodine with formation of hydriodic and sulphuric acids, thus—

$$SO_2+2H_2O+I_2=H_2SO_4+2HI.$$

3.2 gr. sulphurous acid neutralize 12.7 iodine.

Of the gas, 1 part in 100,000 of air is perceptible to the nose; 9 parts are disagreeable and provoke cough; 20 parts are irritating, and 43 parts (=4 parts in 10,000) are irrespirable: much less than this will kill plants (Letheby, loc. cit.). In generating it by burning sulphur in air, 32 parts by weight combine with an equal quantity of oxygen to produce 64 parts of sulphurous anhydride, which occupy precisely the same bulk as the oxygen consumed. Its density is high, the sp. gr. being 2.247; a cubic foot weighs about 1,206 gr., and to produce it 603 gr. of sulphur and a cubic foot of oxygen (=5 cubic feet of atmospheric air) are requisite (Letheby: *Medical Times*, ii., 1873).

Alkaline sulphites and *hyposulphites* owe their properties to the sulphurous acid liberated from them, and although not officinal are often prescribed.

Sodæ Sulphis—Sulphite of Soda.—Prepared by saturating a solution of carbonate of soda with sulphurous acid gas, and crystallizing. It occurs in white efflorescent prisms which have a slight alkaline reaction, and the odor and taste of sulphurous acid; soluble in cold water (1 part in 4), and in less than 1 part boiling water.

Sodæ Hyposulphis—Hyposulphite of Soda (*Appendix B. P.*).—Prepared by gently warming a solution of sulphite of sodium with finely-powdered sulphur, or by passing sulphurous acid gas through it. Occurs in colorless crystals (oblique rhombic prisms); bitter, slightly alkaline, and sulphurous in taste, less unpleasant than the sulphite. Very soluble in water, not in alcohol; decolorises iodine solutions, and dissolves salts of silver which are commonly insoluble, *e.g.*, the chloride. A solution of hyposulphite is distinguished from one of sulphite by the precipitation of sulphur on adding sulphuric acid. Hyposulphites do not act on iodide of potassium.

Potassæ Sulphis—Sulphite of Potash.—Prepared by saturating a so-

lution of potash carbonate with sulphurous acid gas, and crystallizing. It occurs in white opaque fragments or powder, with slight odor of the gas—very soluble in water (1 in 3). Taste saline and sulphurous.

Magnesiæ Sulphis—Sulphite of Magnesia.—Contains proportionately more of the acid (gas) than any other; it is also the most soluble, and the least unpleasant (Polli).

Calcis Sulphis—Sulphite of Lime.—Is soluble only in 800 parts water, but the bisulphite and hyposulphite are freely soluble.

Absorption and Elimination.—*Sulphurous acid* is readily absorbed, and its characteristic odor has been observed in the breath and secretions after its administration (Dr. George Wilks: *British Medical Journal*, ii., 1870). It passes out also with the urine and fæces as sulphate or sulphuric acid, for it is readily oxidized in the system.

The sulphites are decomposed in the stomach by the gastric acid, sulphurous acid is given off, and they are mostly changed into sulphates (Kletzinsky), and are eliminated as such, partly by the intestinal canal, but chiefly by the kidneys (Bartholow); they pass within twelve to twenty-four hours after administration (Polli).

The hyposulphites undergo similar changes, but more slowly, for they are more stable.

After very large doses, these salts may be found unchanged in the urine (Rabuteau), and, after their application to wounds, free sulphuric acid may be traced in the same secretion (De Ricci).

Physiological Action (External).—Externally applied, sulphurous acid is refrigerant, somewhat astringent, and in full strength irritant. The most important property of the gas and its compounds is that of arresting fermentation, and of destroying the lower forms of vegetable and animal life, and certain infective organic poisons. Its power of controlling ferments and destroying visible *parasites* is readily proved, but its action on infectious organic *particles*—a true "disinfectant" action, by which they are rendered inert—is not so capable of demonstration, because the poison itself, the essence of infection, has not yet been verified and isolated; still, as Dr. Sansom observes, "we know that such poison is ponderable, that it obeys physical laws, and is active for long periods, though so minutely divided as to be undemonstrable by ordinary direct physical means" (*British Medical Journal*, ii., 1872). The diffusion-experiments of Chauveau and Sanderson have proved, at least for vaccinia, variola, and sheep-pock, that the poison is solid, insoluble, and indiffusible; and, to judge from its effects, its extraordinary power of multiplication, etc., either it must have some properties of living matter, or act by a process of catalysis or fermentation: the former seems more likely, but however it be, if we make evident that sulphurous acid can prevent or arrest the development of the bacteria, monads, and germs of fungi, etc., which accompany decomposition, it is by analogy probable that it can

exert a similar effect on the minuter particles which constitute infective poison. In proof of the former fact, among other experiments, Dr. Sansom placed cubes of egg-albumen under glass covers with solutions of permanganate, of aluminium chloride, of carbolic and sulphurous acids; and, with the two latter agents, notably with the last, secured almost complete preservation, even after the admission of air (*British Medical Journal*, loc. cit.). For aërial disinfection, Hoppe-Seyler, after careful trial, found sulphurous acid gas the best agent,—1 or 2 per cent. of it in the air of a room destroying all the lower organisms: this could be secured by burning ½ to 1 dr. of sulphur for each 100 cubic feet of space (*Lancet*, ii., 1871, p. 304).

Letheby arrived at similar conclusions, but recommended, for greater security, a larger proportion of sulphur—1½ oz.—to each 100 cubic feet of air (*Medical Times*, ii., 1873).

Dr. Baxter, taking up the same question from another point of view, concluded not only that sulphurous acid was the best of aërial disinfectants, but that its action on vaccine virus was more potent than that of chlorine or carbolic acid. Thus he vaccinated one arm of a child with points of virgin lymph, and the other arm with points previously exposed to the action of the three agents, and while small vesicles often resulted after the use of chlorine or carbolic acid, *none* could be obtained after sulphurous acid, "even under conditions which seemed to render the virulent particles least susceptible to destructive influences" ("Sixth Report of Medical Officer Privy Council," N. S., and *Lancet*, i., 1876). It is true that Dr. Dougall had found sulphurous not so effective as other mineral acids (notably chromic acid) in preventing the decomposition of organic solutions, but Crace Calvert showed this was not correct, and 1 part of the former in 1,000 of albuminous solution was enough to preserve it for forty days, while other acids only preserved it for nine or ten days. Dr. Fergus also compared glasses of beef extract heated with sulphurous acid, carbolic acid, and terebene, and found several weeks afterward that the one heated with sulphurous acid remained quite sweet while the others were decomposed (*Practitioner*, i., 1877).

Physiological Action (Internal).—From the preceding and many other observations, there can be no doubt of the disinfectant power possessed by sulphurous acid in a very high degree when brought into *direct* contact with infective or putrescent material, whether in the air, or in wounds, etc., but the further question whether it can be so introduced into the circulating blood of living animals as to neutralize a septic poison therein also circulating, or so as to prevent the admission of such poison, is more difficult to resolve. Dr. Polli (Milan) held the affirmative to be proved by his experiments upon dogs with sulphites and hyposulphites; after treating an animal with these medicines, he injected septic poison, and found it did not succumb to the effects, while a healthy but untreated

animal quickly did so. In other cases, examining the bodies of animals killed after sulphite treatment, they were found to decompose much less quickly and less readily than others not so treated. He offered, also, some clinical evidence of the value of these remedies in septicæmia, and much practical benefit was expected from his observations; they have not, however, yet passed the region of controversy. Semmola, O. Weber, and others, deny them, or characterize them as "negative." Clinical results differ, and although I hold that much may be done by introducing "disinfectant" medicines, especially sulphurous acid, into the organism, I acknowledge that definite proofs of their power and mode of action within it are still to be desired (*v.* p. 243, also Carbolic and Salicylic Acids).

Digestive System.—Sulphurous acid solution may be taken internally in moderate doses and well diluted without definite effects on the healthy body, unless it be the quenching of thirst and some refrigerant action. Insufficiently diluted, the solution excites local irritation of the digestive tract, some persons being more sensitive to this than others. The sulphites and hyposulphites in large doses increase peristalsis, and cause purging, though not so readily as sulphates.

Temperature.—Given during the pyrexial state, *e.g.*, of remittent fever, sulphurous acid is said to lower the body-temperature.

Synergists.—Disinfectants and antiseptics generally, aid the action of sulphurous acid, but it is so readily oxidized that it is better used alone. Steam favors the aseptic action of the gas, and nitre added to the burning sulphur makes it more effective (Dewar).

Antagonists.—All oxidizing substances alter the chemical constitution of sulphurous acid, and impair the peculiar properties of sulphites, especially when in solution. The mineral acids, including sulphuric, decompose sulphites and hyposulphites.

Therapeutical Action (External).—*Parasitic Skin Disease—Favus—Ringworm.*—Sulphurous acid solution is a cleanly and efficient mode of treating these maladies, as first pointed out by Sir William Jenner (*Medical Times*, ii., 1853, p. 181). It may be painted on occasionally in full strength, or used in lotion or compress, 1 part to 2 or 4 of water and glycerin—the great point is to secure its thorough contact with the diseased surface.

Pityriasis Versicolor (*Chloasma*).—A weaker lotion than the last-mentioned, 1 part in 8, or one containing sulphite or hyposulphite of soda (℥ j. in ℥ viij.) will cure this disorder.

Pruritus Vulvæ, etc.—When pruritus is dependent on discharge, or other source of irritation, possibly parasitic, injections and lotions containing "bisulphite of soda" (gr. xv. ad ℥ j.) have been found serviceable (*Lancet*, ii., 1871, p. 454). The itching of lichen and of true prurigo senilis may also be relieved by lotions containing sulphites.

Erysipelas.—A sulphurous lotion will often give great relief to the burning pain of erysipelas, and its constant application is said to cut short the malady. Dr. Hewson records twenty-seven cases of various degrees of severity—seven of them idiopathic, and all treated by the local use of a sulphite lotion (sodæ sulphitis gr. x. ad ℥ j.) applied on lint covered with oiled silk; it bleaches the skin and "destroys the inflammation" (*Philadelphia Medical Times*, i., 1868). Mr. Pairman describes great and immediate relief to pain in a severe case of facial erysipelas from a lotion of equal parts of glycerin and sulphurous acid: the patient recovered at the end of a week, but tincture of steel and other remedies were given internally; relief, however, was clearly traceable to the lotion, and it deserves to be more generally used than it is at present.

Chilblains—Corns—Fissured Nipples, etc.—For these minor, but annoying ailments, sulphurous acid is a good remedy. Mr. Pairman applies the strong solution of the acid on lint covered with oiled silk: if the skin be broken, the acid should be diluted. Sore nipples are to be "soaked well with strong acid for a few times" (Pamphlet: "The Great Sulphur Cure," 13th ed., 1868). Mr. Fergus applies the acid in spray to chilblains, or uses as a wash 3 parts of the solution to 1 of glycerin and 1 of water (*Lancet*, ii., 1870, p. 769).

Bruises—Sprains.—The same surgeon, who speaks from good experience at Marlborough College, has found a lotion containing sulphurous acid very useful in "every kind of bruise and sprain." He recommends a spray of pure acid for six or seven minutes till the part feels cold, then lotion (1 in 8) to be applied and frequently changed; in forty-eight hours inflammation and pain have subsided, and on the third or fourth day the limb can be strapped or bandaged.

Wounds—Fractures.—Mr. Fergus records also excellent results from the acid used in lotion to a compound fracture and to a severe contused wound of the face (where it is always important to avoid scarring): under a lotion of 1 part in 7 constantly applied, the wounds healed quickly and without suppuration. Dr. John Balfour has had marked success with a lotion (1 in 12) applied on *thin* rag kept constantly wet for the first day or two after injury, afterward wetted every twelve hours with tepid lotion kept covered by oiled silk, zinc ointment being substituted about the third or fourth day. Severe compound fractures of the hand with laceration of tendon, and gunpowder burns, fractures of the shoulder and other joints by machinery—all did well under this treatment, which seemed to give almost instant relief from pain, to control and greatly restrain suppurative action, and secure primary union whenever possible. (*Edinburgh Medical Journal*, June, 1869, November, 1871). Mr. Pairman notes its value in quickly curing a "hack" in horses.

Ulceration—Gangrene.—In cases of unhealthy open wounds, and even hospital gangrene, sulphurous acid has sometimes proved more

efficacious than carbolic; this was especially seen in hospitals at Metz during the Franco-Prussian war (*Medical Times*, ii., 1871, p. 358).

Angina.—In various forms of sore throat, sulphurous acid in gargle, or preferably in fine spray, is exceedingly useful, relieving pain, lessening inflammation, destroying parasitic growth, and cleansing unhealthy suppurating surfaces. It is, in my experience, of great value in *aphthous* conditions such as occur during phthisis or other exhausting diseases, as well as in the ordinary form common during infancy; it often relieves the pain, tension, and ulceration of scarlatinal and variolous throats, and I have seen it of the greatest service in chronic syphilitic ulceration of the fauces.

In the acute inflammatory stage of catarrhal angina, it is not always well borne, but will be found to answer better in such cases when used of full strength, if only for a very short time, than if diluted; in the latter case, it has seemed to irritate the mucous membrane without controlling inflammation, but there is no *one* rule, a short trial will be the best guide; young children do not usually bear it well. Fergus, on the other hand, says it is good "in all forms of inflammation of the throat and tonsil;" it should change the turgid redness to a light pink during the application.

Dysphonia Clericorum—Follicular Pharyngitis.—Dr. Dewar has published cures of this condition, so rapid and after so many years' duration of the malady, as to border on the marvellous. One clergyman, a sufferer for twenty years, found immediate relief from the spray—"something loose, feeling braced up;" and others suffering also from general weakness, night-sweats, nervousness, partial aphonia, etc., are said to have been restored by sulphur fumes and spray. The cases are described in popular language rather than with scientific accuracy, but we may accept the fact of much relief being afforded in the class of maladies referred to (*Medical Times*, i., 1867, p. 545).

Catarrh—Hay Fever.—A sulphurous acid spray applied to the nostrils often relieves the annoying symptoms of both these maladies. Sulphur-fumigation is also said to have cured them quickly (Dewar, Pairman), but this cannot always be depended upon (McGregor: *Edinburgh Medical Journal*, October, 1869).

Chronic Bronchitis.—The spray is sometimes a useful adjunct in the treatment of this condition; it acts as a stimulating expectorant, thinning the tough viscid phlegm; sulphur-fumigation is also good (Fergus). It will not, however, accomplish the wonders at one time expected from it, and should be commenced cautiously.

Asthma.—In this capricious malady, sulphurous sprays and fumigations have been tried, and apparently with advantage, but more often with marked increase of irritation; as a rule, other remedies relieve more.

Phthisis.—Dr. Dewar has recorded a remarkable case in the person of

a groom advanced in phthisis, with emaciation, cough, sweatings, hæmoptysis, etc., and apparently in a hopeless condition, who conducted sulphur-fumigations for cattle (*v.* p. 242), remaining with them in the sheds "with the most wonderful benefit to his own health: within one week the night-sweats had ceased, his cough abated, and expectoration diminished; he gained weight—nearly two stone in four months: is now dependent for his life on one lung only, or nearly so, but with the exception of being somewhat short-winded, looks nearly as strong and as able for ordinary work as before his illness" (Pamphlet: "On the Application of Sulphurous Acid Gas," 1866). He reports four other cases of "chronic phthisis" equally benefited; and Mr. Pairman corroborates his observations; they deserve careful consideration, but up to the present there has been little further trial of the method.

It was thought that the sulphurous *spray* would be of great service in the relief of phthisical symptoms, but I have not seen lasting or important results from it, though it facilitates expectoration and lessens laryngeal irritation.

Fumigation in Infectious Disease, etc.—The burning of sulphur for the prevention or cure of infectious disorder long preceded any modern scientific inquiry. The Chinese esteemed it highly in prehistoric times. Ulysses, according to Homer, employed it to disinfect his palace after slaughtering the suitors, calling it "the remedy of all evils, and cure of all sores" ("Odyssey," Book xxii., line 481, etc.). Ovid praises it in the "Fasti," and Pliny in his "Natural History;" but it is within quite recent years, and since the recognition of a "germ theory" in disease, that the systematic use of sulphurous acid, *within*, as well as without, has been placed upon a logical basis or fairly pressed upon the profession as a method of treatment.

When cattle plague was epidemic, Dr. Dewar found the best results from fumigating cattle sheds with sulphurous acid. His own cattle never suffered, and "a large dairy, notorious for thirty years for mortality among its cows (from pleuro-pneumonia), and which for eight years of the then tenant's occupancy had never been free from disease for a month, in which sixteen cows had lately died, the last, three days before fumigation began; this dairy from that time till the date of writing had been perfectly healthy." He states also that "an epidemic of diphtheria was cut short by it; two cases having occurred in one house within twenty-four hours, and no others after sulphur-fumigations." Mr. Pairman reports similar experience, but it must be said that neither author, however earnest and truthful in reality, writes in such a manner as to convince the profession, and hence, perhaps, they have not yet widely influenced ordinary practice.

The variola epidemic, arrested on the coast of Iceland by Dr. Hjaltelin, seems to me admissible evidence of the value of the gas, though even

this arrest has by some been attributed to the quarantine and isolation enforced. Twenty-two cases were brought on shore from the fishing vessels; seven were confluent; only one died (moribund on admission); *in no instance did the disease spread.* A workman employed in the hospital did not catch small-pox, although shortly after he proved susceptible to vaccination; in every case the attack was quickly and favorably modified: results which may fairly be connected with the treatment—constant use of sulphur fumes in the air, and the giving of sulphurous solution internally (*British Medical Journal*, ii., 1871). (An epidemic of small-pox in the last century—1707—destroyed one-fourth of the population of the same country).

Dr. A. W. Foote, during the last epidemic of variola in Dublin, endeavored to carry out a thorough disinfectant treatment in his wards at the Meath Hospital, giving sulpho-carbolates as well as sulphurous acid, applying the latter locally, and burning sulphur three or four times a day; he treated 59 cases, of which 24 were confluent, 6 semi-confluent, and 11 died, and he concluded that the treatment was of value, and that sulphur vapor acted "as a prophylactic," but was irritating to bronchitic subjects. This fact is important, for in confluent small-pox, laryngitis is a frequent and serious complication (*Dublin Journal and Medical Times*, April, 1872).

On the other hand, we have to note unsatisfactory results from the use of similar treatment during an epidemic at Trinidad. Dr. Bakewell, though not furnishing many details, states that he treated twenty-five patients with sulphur-fumigations and sulphurous acid, apparently "without any effect" (*Medical Times*, i., 1872).

The experience of Mr. Fergus as to disinfection after an epidemic of scarlatina is very favorable: upwards of 4,000 blankets and other articles of infected bedding and clothing were exposed thoroughly for four hours to the fumes of burning sulphur, "with complete success" (*Practitioner*, i., 1877). He is accustomed to depend on a short personal exposure to sulphur fumes after visiting an infectious case, and has never conveyed infection in his own person. He lays stress upon an important point, inattention to which might possibly account for some failure: the vapor should be used at intervals for half to one hour at a time, and at its full strength, rather than by being constantly given off at low tension—the latter method is apt to be ineffective, as well as more likely to give rise to unpleasant sulphur combinations.

The acid bleaches vegetable colors, and corrodes metals, etc., but not so markedly as to cause inconvenience in practice. The pernicious effect on human air-passages, formerly attributed by high authorities to effective sulphur vapor has been quite disproved. Dr. Angus Smith says, "This acid gas is an irritant, and causes coughing, which becomes painful and dangerous according to the amount used, and as it is destructive to

animal structures it does not seem advisable to use it more than can be avoided" (On Disinfectants): such an opinion has doubtless told against its use, but after the observations of Dewar, Pairman, Fergus, and others, must now be modified.

Cholera.—The burning of sulphur fires round infected villages has been strongly urged (Tuson: *Lancet*, ii., 1876, p. 313).

Mode of fumigating with Sulphurous Acid Gas.—Dr. Dewar, referring more particularly to the process as applied for cattle plague, recommends as the safest and most convenient apparatus, "a chaffer two-thirds full of red cinders, a crucible inserted therein, and a piece of sulphur stick"—"a piece" the length of a man's thumb will burn for twenty minutes and be sufficient for a shed containing six cattle, and if ventilation be free at the same time, a man can remain without the least risk of detriment—this is repeated three or four times daily. Its efficacy is increased by simltaneous steam-fumigation, and if only "inanimate objects" are to be disinfected, nitre may be added to the sulphur, and thus some sulphuric acid generated (Pamphlet, pp. 7–21).

For phthisical and other patients, the room is simply filled with fumes three times a day. Mr. Pairman places half a teaspoonful of sulphur on paper on a shovel and ignites, repeating this process every twenty minutes till the patient has had one or two hours of fumigation;—the head should not be held too near, nor the fumes made so strong as to excite much coughing. He is in favor of keeping "mild sulphur fumes almost constantly in the sick room," but the occasional and temporary use of a full dose is to be preferred. Dr. A. W. Foote "used" flowers of sulphur dropped on a heated shovel, and carried about the room, and this is quite under control and readily borne by patients unless bronchitis or asthma renders them unusually sensitive. From 1 to 2 dr. will be an average quantity: it is scarcely necessary to make an exact calculation.

If a room is to be thoroughly disinfected in the absence of inmates, the doors, windows, and other apertures should be closed—pasting paper over chinks is sufficient—colored clothes removed, and metal protected by grease or otherwise; then sulphur should be burnt in quantity proportioned to the space, taking Lethcby's estimate of $1\frac{1}{2}$ oz. for each hundred cubic feet, or more roughly the proportion of $\frac{3}{4}$ lb. for a large room (Fergus). If dried and finely powdered, it will burn when lighted, and may be conveniently placed in a small earthern jar standing in water: mixed with $\frac{1}{10}$ part of its weight of powdered charcoal it burns, perhaps, more readily, and will not melt and run over—the charcoal will be unconsumed (Fergus). If this mixture be placed on an iron plate two feet square it will be safe, though for precaution some would put the plate or vessel over water. After an hour's fuming, a free current of air should be admitted for several hours before occupying the room. Mr. Keates, the chemist, has suggested the burning of bisulphide of carbon as a conve-

nient means of obtaining gaseous sulphurous acid, for much more of this gas is given off than of carbonic acid—especially is this the case if petroleum be mixed with it. In a room of 1,300 cubic feet, 280 gr. bisulphide charged the air so efficiently with SO_2 that one could not remain in it, and a lamp has been contrived to burn a graduated amount (*Lancet*, ii., 1876, p. 712). It is said too that the offensive smell of bisulphide is got rid of in the purer preparations (Price & Co.), but still it remains highly inflammable, and the method seems more dangerous and more complex than simple sulphur burning.

Therapeutical Action (Internal).—Following up the observations already mentioned as to the effect of sulphites upon dogs, Prof. Polli devised a special method of treating "zymotic" diseases—the "anti-fermentative, or anti-zymotic method," which aimed at prophylaxis by saturating the blood with these remedies. The method made progress in Italy, Spain, and France, not much in Germany, and lately it has lost ground even in the former countries (Nothnagel); still I think that with modifications it has a future before it, and will mark a distinct advance in rational therapeutics. It is applied not only to the specific fevers, cholera, intermittents, and the like, but also to pyæmia and septicæmia generally.

Septicæmia.—Dr. Polli, Dr. De Ricci, and others, have recorded cases of pyæmia, phthisis with suppuration, chronic empyema, etc., benefited by sulphites.

Mr. Spencer Wells traced improvement in septicæmic uterine cases to the use of hyposulphites (*Medical Times*, ii., 1864).

McCall Anderson cured eruptions of furunculi with ½-dr. doses of sulphite of soda (*Lancet*, i., 1870, p. 897), and Dr. Ricci, chronic pemphigus with sulphite of magnesia (*Dublin Journal*, vol. xxxvi.). Dr. C. B. Radcliffe, when suggesting the use of the same salt in cattle plague, states that he has seen good results from it in fevers (*Lancet*, i., 1870, p. 897).

Snow Beck used frequent vaginal injections of sulphite of soda in puerperal fever, and gave internally the sulphites of lime or magnesia, and advocated this treatment as better than any other (*Lancet*, i., 1865, p. 340). Sulphite of soda in 2-dr. doses daily (readily taken in beef-tea) proved valuable in pyæmia in the Liverpool Infirmary (*Medical Times*, ii., 1868, p. 336), and Dr. Miller, while reporting the hyposulphite ineffectual in typhus, found it distinctly of service when given early in septicæmic cases connected with parturition (*Edinburgh Journal*, September, 1869). This is not a large amount of evidence, and, though more might be collected from foreign sources, it would not be enough to place this medication yet on an assured basis, but considering how serious a condition is in question, it well deserves further inquiry. Of course, if blood-poisoning have reached beyond a certain point, recovery is not possible under any treatment, and if the salts employed be not fresh and pure,

failure also will result; irritation of stomach and intestinal tract may also hinder their employment, and I think that sulphurous acid is really a better form to employ than its alkaline compounds; but whichever be chosen should be *early* and thoroughly given. There is no objection to combining this medication with the internal use of aconite, and with all recognized remedies to promote elimination.

Variola.—We have already stated that in the hands of Dr. Hjaltelin and Dr. A. W. Foote, the internal use of sulphurous acid solution in small-pox was combined with the external application of the gaseous form, and, so far as could be judged, with good effect. The secondary fever of this malady is due to absorption from the pustular eruption, and this ought to be influenced by the early employment of such remedies, and I believe is so influenced. In one exceedingly severe case of confluent small-pox, considered hopeless by a good practitioner, the patient was enabled to take ½-dr. doses of sulphurous acid every hour or two, and within a short time showed signs of improvement, which went on to complete recovery, not in accord with the normal rate of progress in such cases. To variolous pustules maturating the acid with glycerin is a good application.

Erysipelas.—The relief given by the acid spray in erysipelas by Dr. Hewson and Mr. Pairman has been already noted, but the internal use of the remedy may be well conjoined with the external. In the case of an infant living under unhealthy conditions, and in whom a severe attack of the idiopathic malady affected one arm and leg, the pudenda and head, and when iron had no control over it, the internal use of sulphurous acid seemed the cause of improvement which very quickly followed.

Diphtheria.—Under sulphur it has been stated that the local application of that remedy is not desirable (*v.* p. 30), but sulphurous acid acts very much better, and is, as a rule, well borne, and even liked by the patient.

Dr. Dewar and Mr. Pairman used it rather in fumes and spray or gargle, and conjoined with it iron or chlorate of potash. Dr. Joyce (quoted by Dr. Geo. Johnson, *Lancet*, i., 1875, p. 82) had the best results from the same practice (with iron). Fergus depends on the acid with ice only, and other observers have had satisfactory results from the salts: thus Dr. Hayden from the hyposulphite (*Dublin Quarterly*, August, 1866). I think the local application of the acid in spray highly desirable.

Enteric Fever.—While recognizing the difficulty of a true judgment about the effect of medicines in this fever on account of some uncertainty in its natural course and duration, and of the usual recoveries independently of any specific treatment, yet I must state my conviction that its course may be favorably influenced by the internal use of sulphurous acid, if commenced *early* enough. I know that many of the highest authorities have taught that the fever-poison having once been received must pass through certain changes before elimination, and that the best

practice is mainly,—intelligent nursing; but careful observation of many enteric cases has led me to the conclusion that in some instances, under the influence of the administration of sulphurous acid or the sulphites, the attack has been shortened, and in others, high temperature and profuse diarrhœa have been relieved, coincidently with improvement in the general symptoms. In some advanced cases, with muttering delirium, sordes, and signs almost of dissolution, a favorable change has occurred shortly after commencing the acid treatment. Of thirty-six consecutive cases thus treated by Dr. Mackey, several illustrated these points, and none died. Special advantage from the acid is not claimed on the score only of the number recovered, for equal results have been recorded from other methods: the number is still too small to justify positive conclusions, but the impression made on my own mind as to the value of the acid is highly favorable.

It is true that sometimes unusual or persistent vomiting interferes with its administration, and the drachm or two-drachm doses recommended cannot always be given: 10 to 30 drops has been an average dose for an adult, when repeated every two to four hours, and when urgent bronchitis contra-indicates this remedy, for a time expectorants and diaphoretics must be substituted. Several years ago, Dr. Hamilton (Liverpool), treating his last eight cases of an epidemic of typhoid with sulphurous acid, "was struck by the mild form assumed, and apparent cutting short of the fever." They were typical cases at the commencement—five children, three adults—and the dose was from 1 to 3 dr.; they were generally better on the second day, and by the fifth day improvement had set in (*Lancet*, i., 1869, p. 45). Dr. George Wilks, of Ashford, refers to 171 cases of enteric fever treated by him with sulphurous acid, and all ending in recovery, some under very unpromising conditions; thus he instances a poverty-stricken child of four years, with violent vomiting, purging, tympanitis, and delirium, who could not have ordinary care and attention; a woman of seventy-three equally neglected; and a man of fifty-four apparently dying under ordinary treatment of astringents, etc., and yet rapidly recovering after commencement of the acid treatment (*British Medical Journal*, ii., 1870). The patients took from 2 to 20 drops with syrup and water every four hours for many days, until they showed ample evidence of the absorption and elimination of sulphur. Dr. Skinner reports twenty cases of enteric fever treated by sulpho-carbolate of soda (with one death).

Dysenteric Diarrhœa—Cholera.—Dr. Scoffern writes recommending the sulphite of lime in choleraic diarrhœa (*Lancet*, ii., 1866, p. 279), but it has not been much used. On the hypothesis of cholera being dependent upon the absorption of organic poison, sulphurous acid ought to prove of some service in its treatment, more so than the sulphites and hyposulphites, which are slower in action and liable to irritate. Professor Gra-

ham, indeed, first introduced the solution of sulphurous acid to Sir Wm. Jenner as a possible remedy for cholera, but it has never received full trial. A main difficulty, as regards any remedy in cholera, is to secure its absorption, all vital function being annihilated with such fearful rapidity: hence we can never hope for the same results as in enteric fever, but sulphur fumes should certainly be used as disinfectant and prophylactic.

It has been pointed out that workers in copper, and in powder factories (at Madras especially), have shown special immunity in cholera epidemics, and although Dr. Burq claims specific virtues for copper in this respect (*v.* Cuprum), the presence of sulphurous acid is a more likely explanation (*Lancet*, ii., 1873).

Ague.—The hypothesis of ague being dependent upon the absorption of minute fungi or spores given off by the soil of malarious districts has been forcibly maintained by H. Schmidt, Salisbury, and others, who have even reported the finding of such microscopic organisms in the blood and secretions of patients, and in the neighboring marshes (*Lancet*, ii., 1867, p. 588). Evidence in favor of this theory seems furnished by such instances as that of the ship *Argo*, which took on board for (water supply to) a band of soldiers, water from a malarious district, and almost all who drank of it got intermittent fever, while the *sailors* of the same vessel, who had a different water supply, did not suffer (*Lancet*, loc. cit). Still, the hypothesis is not proved, and clinical evidence as to the value of sulphite treatment is contradictory—thus, while Sanger refers to four cases of intractable ague, soon relieved and ultimately cured by scruple doses of hyposulphite of soda (*Lancet*, i., 1869), McClean criticises the result, and notes that quinine and other remedies had been previously used, and that it it is well-known quinine often does not cure, unless a blood depurant, such as potash or soda first be given, and moreover many cases in the Mauritius were treated by the sulphites without effect, and were afterward cured by quinine (*Lancet*, i., 1869, p. 511). Several American writers have reported the cure of intermittents by hyposulphites after failure of quinine (Ranking, Abstract, ii., 1868, ii., 1870), but Farelli, from an exhaustive analysis of the recorded evidence, concludes that their good effect is neither so quick nor so constant as that of the latter; they are not prophylactic, and their continued use leads to anæmia: he holds that their action, such as it is, "is reductive, not disinfectant" (Abstract, *Lancet*, i., 1873, p. 634).

Syphilis.—Several writers, chiefly American, have strongly recommended the internal and external use of the sulphites in the later stages of syphilis (Ranking, ii., 1868). I have had no occasion to prescribe them, but have found the acid locally applied most useful in throat and other ulcerations. Dr. Purdon has recorded an illustrative case (*British Medical Journal*, i., 1868).

Pyrosis—Sarcinous Vomiting.—In these conditions, which are clearly dependent more or less upon fermentations or the presence of low organisms, the influence of sulphurous acid and its compounds ought, *à priori*, to be clearly shown, and so practically we find it, for sulphurous acid in ½-dr. doses is one of the best remedies that can be given. Sir William Jenner was one of the first to point this out (*Medical Times*, ii., 1853), and Dr. Henry Lawson, one of the first to secure for it the attention of the profession (*Practitioner*, vol. i.). C. Drysdale also early recorded a case rapidly relieved by this treatment after failure of bismuth, prussic acid, etc. (*Lancet*, ii., 1869). Other physicians have succeeded with the hyposulphites (*Medical Times*, i., 1853), and even with sulphites, and if Dr. Lawson found no benefit from these, as compared with the acid itself, it was probably because his dose was but small: the hyposulphites, however, must deposit sulphur, and as a rule, the acid will be found best.

Preparations and Dose.—*Acidum sulphurosum:* dose, ½ to 1 fl. dr., diluted. For external application the solution may be used in full strength, or diluted with equal parts of glycerin and water, or as a lotion 1 part in 8. *Sodæ sulphis:* dose, 20 to 60 gr., freely diluted: as a lotion (antiparasitic), 1 part in 8: as an injection, etc., 2dr. to ½ oz. in 8 oz. of fluid. *Sodæ hyposulphis:* dose, 20 to 60 gr. *Calcis sulphis:* dose, 10 to 20 gr. *Magnesiæ sulphis:* dose, 10 to 30 gr. *Potassæ sulphis:* dose, 10 to 30 gr.

[All the foregoing, except *Calcis sulphis* and *Magnesiæ sulphis*, are officinal in the *U. S. Pharmacopœia.*]

ACIDUM TARTARICUM—TARTARIC ACID, $H_2C_4H_4O_6$ (or H_2T),=150.

An organic acid very widely diffused: it occurs in fruits partly in the free state, and partly combined with potash or lime.

Preparation.—From "cream of tartar"—acid tartrate of potash—which is derived from grape-juice. The process of preparation involves three distinct reactions: (it is a favorite test-question at examinations).

1. The salt having been boiled with sufficient water, prepared chalk is gradually added, and an *insoluble tartrate* of lime is formed and precipitates: but tartaric acid is dibasic, and the other equivalent of basic potash remains in the solution as a *neutral tartrate* (K_2T).

$$2(KHC_4H_4O_6)+CaCO_3=CaC_4H_4O_6+K_2C_4H_4O_6+CO_2+H_2O.$$

2. To precipitate this element of tartaric acid also as tartrate of lime, solution of chloride of calcium is added, giving rise to formation of chloride of potassium, and precipitating the tartrate of lime.

$$K_2C_4H_4O_6+CaCl_2=CaC_4H_4O_6+2KCl.$$

3. The tartrate of lime, having been washed, is decomposed by sul-

phuric acid, which precipitates an insoluble sulphate, tartaric acid being left in solution.

$$CaC_4H_4O_6 + H_2SO_4 = H_2C_4H_4O_6 + CaSO_4.$$

Characters and Tests.—Tartaric acid occurs in fine white powder, of strongly acid taste, or in large colorless oblique rhombic prisms, which become luminous in the dark on friction. While dry, these are permanent in air, but an aqueous solution becomes mouldy on keeping, with formation of acetic acid (a change which may be prevented by the addition of some rectified spirit). A usual test for tartaric acid in solution (not too dilute) is the formation of a crystalline white precipitate of tartrate of potash on the addition of acetate of potash. Solutions neutralized by an alkali also give with chloride of calcium a white precipitate of tartrate of lime soluble in cold liquor potassæ, but falling again when heated. Tartaric acid may be added to bicarbonate of potash to saturation without any precipitate, but if the bicarbonate be added to the acid, bitartrate is at once formed and precipitates (Squire).

Absorption and Elimination.—Tartaric acid, in moderate doses, is readily absorbed, but we do not exactly know what changes it undergoes in the system. That it combines with earthy bases is probable, for Wöhler found it in the urine (by which secretion it is eliminated) in the form of tartrate of calcium (*Medical Times*, ii., 1845). Dragendorff, Buchheim, and Pietrowski found only a small amount in the urine, and conclude that the greater part is oxidized in the body.

Physiological Action (External).—On the skin, concentrated solutions of tartaric acid produce temporary irritation and burning.

Physiological Action (Internal).—*Digestive System.*—Small doses have a cooling taste and quench thirst, but, if continued, may irritate the stomach, and large doses cause purging.

Very large quantities have toxic effects, though not of so severe a kind as those of oxalic, or even of citric acid (Husemann). A fatal result is very rare, but Taylor records one in which death followed nine days after taking 1 oz. of tartaric acid in solution: the symptoms and appearances were those of gastro-enteritis. In other cases the mucous membrane of the stomach and the intestines has been found either white (not inflamed) or ecchymosed, with partial softening.

Circulatory System, etc.—Bobrick reported weakening and slowing of the heart-action in frogs, rabbits, and men, after large but non-toxic doses; the vagus nerve was not concerned in this effect (Husemann: *Arzneimittellehre*, ii., 894). According to Mitscherlich, rabbits die from doses of 3 to 4 dr. with symptoms of adynamia, weakened heart-action, and difficult respiration; the blood is found fluid, in some cases light, in others dark-red.

Bence Jones found tartaric acid increase acidity of urine, and lead to excretion of uric acid in a free state (Lectures, 1867).

Synergists.—Citric and other vegetable acids.

Incompatibles.—Alkalies, salts of mercury and lead, and vegetable astringents are incompatible. Lime and magnesia are the best antidotes.

Therapeutical Action (External).—*Fetid Perspiration.*—Schottin states that tartaric acid relieves this unpleasant condition, and I can corroborate the observation. For the feet it may be used sprinkled in the stockings, or these may be washed in a strong solution. The powder may also be rubbed into the axillæ, with the caution that if irritation be produced it must be replaced by some soothing powder.

Therapeutical Action (Internal).—This acid, dissolved and sweetened, is sometimes used as a refrigerant drink; and it exerts a slightly sedative effect on the circulatory system. It is sometimes used in place of citric acid, but is not so pleasant to the taste, nor so well borne by the stomach. Of seidlitz powders, the "white paper" contains about 35 to 40 gr. of this acid, which, when dissolved and mixed with the same quantity of soda bicarbonate and 120 gr. of tartarated soda (the contents of the "blue paper"), forms a sedative, refrigerant, and slightly aperient draught. Annesley considered tartaric acid of service in excessive secretion of mucus by the stomach or intestine. In cases of ammoniacal urine with cystitis from calculi, prostatic disease, etc., I have often found it relieve the symptoms, and render the secretion duly acid and clear: full doses of 20 to 40 gr. well diluted should be given three or four times daily for a short time.

Preparation and Dose.—*Acidum tartaricum:* dose, 10 to 30 gr. or more dissolved in water, and sweetened. For effervescent draughts, 20 gr. neutralize 26 gr. of potash bicarbonate, 22 gr. of the soda salt.

Adulterations.—Oxalic acid and lime, sulphuric acid, cream of tartar, and alum are sometimes found in samples of tartaric acid; also lead, which may be derived from the vessels in which it is crystallized.

AMMONIUM, NH_4,=18.—AMMONIA GAS, NH_3,=17.

Ammonia exists in the air in minute quantity (probably as carbonate), in sea-water and many mineral waters, and rain-water; in the soil and in animal excretions, especially the urine. It is a usual product of decomposing nitrogenous matter, and is said to occur free in certain plants, as in the leaves of aconite and the root of hellebore. The chloride is found native near volcanoes, and in many coal mines.

Its salts are commonly obtained from "gas-liquor," a product of the distillation of coal in gas-manufacture: when this is neutralized by hydrochloric acid, it yields a chloride, NH_4Cl (sal-ammoniac), and from this salt, when purified, are derived all the other ammonium compounds used in medicine.

Characters.—Ammonia itself is a colorless gas, which may be liquefied. It has a pungent odor and alkaline reaction; it forms salts with acids, and, as these are very analogous in chemical relations to salts of potash and soda, it is believed that they have a metallic base, which is named ammonium, and is the fundamental radical of the series. But while potassium and sodium are *simple*, ammonia is a *compound* body or radical (NH_4), acting like a simple one, and until its recent isolation as a blue liquid, its existence was inferred rather than demonstrated (Smith's Commentary).

LIQUOR AMMONIÆ FORTIOR—LIQUOR AMMONIÆ.

Solutions of ammonia gas in water, the former containing 32.5 per cent. and being about one-third stronger than the simple liquor; they are commonly called "spirits of hartshorn," because formerly prepared by heating scrapings of horns and hides.

Preparation.—By heating sal-ammoniac with slaked lime, and distilling, the gas being passed through wash bottles into a receiver containing water.

$$CaH_2O_2+2NH_4Cl=CaCl_2+2H_2O+2NH_3$$

Characters and Tests.—The stronger solution is colorless, of sp. gr. .891 to .900, of characteristic pungent odor and alkaline reaction. A piece of moist red litmus paper held in the neck of the bottle is at once turned blue. *The tests for its purity are*—When diluted with four times its volume of water, it gives no color or precipitate (*a*) with lime water, showing the absence of carbonic acid; or (*b*) with oxalate of ammonia, showing the absence of lime; or (*c*) with sulphide of ammonium, proving its freedom from lead, copper, and other metals; or (*d*) with ammonio-sulphate of copper, showing its freedom from sulphuretted hydrogen. (*e*) When rendered acid by excess of nitric acid it gives no precipitate with nitrate of silver or chloride of barium, showing its freedom from chlorides, bromides, iodides, cyanides, phosphates, and sulphates.

The properties of liquor ammoniæ are similar, but weaker in degree.

Compounds of Ammonia.

AMMONIÆ CARBONAS—CARBONATE OF AMMONIA, $N_4H_{16}C_2O_6=236.$

The real constitution of this complex formula is probably,—two molecules of *acid* carbonate, and one of carbonate of ammonium.

Preparation.—By heating a mixture of chalk (carbonate of lime) and sal-ammoniac (chloride ammon.), when chloride of calcium and a

complex carbonate of ammonia are formed; the latter distils over, and is condensed.

CHARACTERS.—When recent it is seen in colorless, translucent, crystalline masses, of strong characteristic odor and acrid taste, markedly alkaline in reaction, volatile, soluble in water, less so in spirit, and effervescent with acids. When exposed to the air it gives off ammonia and carbonic acid, loses its odor, and crumbles into an opaque mass of bicarbonate of ammonium. In consequence of ready decomposition, the aqueous solution of the ordinary salt will contain both neutral and acid carbonates. The neutral salt has not been isolated in the solid state.

AMMONII CHLORIDUM—CHLORIDE AMMONIUM—SAL-AMMONIAC, NH_4Cl, =53.5.

PREPARATION.—Generally from gas-liquor, by adding hydrochloric acid to neutralization, evaporating the liquid, and purifying the crystals by sublimation.

CHARACTERS AND TESTS.—Occurs in pieces of the hemispherical cakes in which it is sublimed, of translucent fibrous appearance and pungent saline taste—inodorous. Its ordinary form is hard to powder. It is soluble in one part of boiling water and three of cold, its solution being attended by reduction of temperature; also soluble in rectified spirit. Heated with potash, soda, or lime, it evolves ammonia.

AMMONII BROMIDUM (*v.* Bromine, p. 98).

LIQUOR AMMONIÆ ACETATIS—SOLUTION OF ACETATE OF AMMONIA.

Acetate of ammonia, $NH_4C_2H_3O_2$, =77, dissolved in water, commonly called spirit of Mindererus.

PREPARATION.—By gradual neutralization of carbonate of ammonia with acetic acid.

CHARACTERS AND TESTS.—When pure and fresh this is a limpid, colorless liquid, without odor and with strong saline taste; but unless carefully kept it soon spoils. With caustic alkalies it evolves ammonia, and with sulphuric acid, acetic vapors.

AMMONIÆ CITRATIS LIQUOR—SOLUTION OF CITRATE OF AMMONIA.

Citrate of ammonia, $3NH_4C_6H_5O_7$, =243, dissolved in water.

PREPARATION.—By neutralizing a solution of citric acid with strong solution of ammonia. It is a colorless liquid of saline taste.

AMMONIÆ PHOSPHAS—PHOSPHATE OF AMMONIA, $(NH_4)_2HPO_4$,=132.

PREPARATION.—By neutralizing phosphoric acid with ammonia, the latter being in excess.

CHARACTERS AND TESTS.—The crystals, which are transparent when recent, become opaque on exposure, and part with ammonia and water. Soluble in water, insoluble in spirit, gives a characteristic yellow precipitate with nitrate of silver.

AMMONIÆ BENZOAS—BENZOATE OF AMMONIA, $NH_4C_7H_5O_2$.

PREPARATION.—By dissolving benzoic acid in water, with solution of ammonia, and crystallizing.

CHARACTERS AND TESTS.—Occurs in colorless laminar crystals, which are soluble in water and alcohol: they are sublimed by heat. Hydrochloric acid precipitates benzoic acid from solution, and caustic potash heated with it causes evolution of ammonia. Per-salts of iron give a yellow precipitate.

Ammonii Sulphidum (*Appendix II.*), $(NH_4)_2S$,=68.—By passing sulphuretted hydrogen into liq. ammoniæ to saturation, then adding more liq. ammoniæ.

$$NH_3+H_2S=NH_4HS \text{ and}$$
$$NH_4HS+NH_3=(NH_4)_2S$$

A colorless liquid, becoming yellow when kept, of disagreeable taste and fetid odor. It is incompatible with almost all metallic and acid solutions.

Ammoniæ Nitras—Nitrate of Ammonia, NH_4NO_3,=80. (Placed in the appendix only for the preparation of nitrous oxide gas.)

ABSORPTION AND ELIMINATION.—Ammonia and its carbonate are not wholly absorbed as such—a part becomes changed into chloride in the stomach (Rabuteau). Most of the free ammonia combines with carbonic acid in the organism (Bellini: *British Medical Journal*, i., 1874). Salts of ammonia with *organic* acids (citrate, etc.) are decomposed in the capillaries, when the acids are oxidized and ammonia is set free. Compounds of ammonia with *mineral* acids form alkaline salts at the expense of carbonates in the blood (Bellini).

Though Lange did not find ammonia in the air expired by animals taking it (*Archiv für Exper. Path.*, Bd. ii.), other observers have often done so, and Bellini concluded that caustic ammonia and the carbonate, when taken in small doses, were entirely and very quickly *eliminated by the lungs;* of large doses, some passed also by other channels. Whatever salt was taken, carbonate was eliminated by the lungs.

There is sufficient evidence that the carbonate, when taken in moderate or even large doses, is not excreted as such by the kidneys. Rabuteau, took 60 gr. daily for five days without finding any in the urine, which continued acid, whereas a mere trace of ammonia added *directly* to the urine suffices to give an alkaline reaction. Dr. Bence Jones had previously pointed out this continued acidity of urine under ammonia, and suggested that the drug becomes so far oxidized in the system as to give rise to nitrous or nitric acid, which appears in that secretion ("Philosophical Transactions," 1851, and *Medical Times*, ii., 1854). Only after very large doses (160 gr. daily) *some* carbonate of ammonia is eliminated in the urine, which then becomes alkaline, and deposits ammonio-magnesian phosphate.

Ammonium *chloride* does not readily decompose in the system; it is excreted by the urine and partly by the saliva (Rabuteau); a small quantity passes out by the skin.

Frerichs taught that in uræmia an unusual amount of ammonia carbonate (arising from decomposition of urea) circulated in the blood and was excreted by the lungs, and, although some doubt has been thrown upon this by Dr. George Johnson and others (*Medical Times*, i., 1858), it certainly occurs in some cases (cf. p. 256). Richardson has pointed out that during an *actual attack* of uræmic convulsion, the amount of ammonia excreted is less than at other times on account of the retention of urea in the system (*Lancet*, ii., 1860). Gull found ammonia, when the albumen in the urine was not large in amount (*Medical Times*, i., 1861, p. 616). Uræmic coma is, however, connected with the circulation of urea, etc., rather than of ammonia (*Medical Times*, i., 1862).

Physiological Action (External).—The vapor of carbonate of ammonia (smelling salts) is stimulant and slightly irritant, that of the strong ammonia is intensely irritant to the whole of the air-passages and conjunctivæ, and has even caused fatal bronchitis. Liquid ammonia is also a strong local irritant; diluted with oil it is "rubefacient," but applied in strength, and evaporation prevented, it vesicates, and if injected under the skin causes severe sloughing. Oertel reported that the direct application of liquor ammoniæ to the air-passages caused a membranous effusion similar to that of croup; but very careful observations by Meyer on the same point verified only a local catarrhal inflammation and hemorrhage (*British Medical Journal*, ii., 1874). Ammoniacal urine commonly irritates the bladder.

Ammonia has marked antiseptic powers: 1 dr. of liq. ammon. fort. on lint under a bell-jar preserves morbid specimens, and the same quantity with water preserves them better than spirit.

Physiological Action (Internal).—*Circulatory System.*—Medicinal doses of ammonia and its compounds quicken the heart's action and capillary circulation, but only for a comparatively short time: such stimu-

lation is not always marked in healthy persons—it is more evident in the weak and in invalids: there is increased sense of warmth, the face becomes flushed, the eyes more brilliant, and the mental condition stimulated.

Ten drops of the liquor, diluted with 1 or 2 oz. of warm water and *injected into a vein*, excite the heart so powerfully as to rouse a patient from a state of collapse (Tibbitts: *Medical Times*, ii., 1872). Larger quantities—30 drops—given in the same manner, after a momentary arrest, stimulate intensely, and may induce convulsion: still larger quantities cause momentary fall of arterial pressure, then sudden and enormous rise, with corresponding increase of pulse-rate: this result occurs equally after division of the cord, hence it is not due to stimulation of the vaso-motor centre, but of the accelerator nerves of the heart (Lange).

On the other hand, according to Rabuteau, 40 grs. of *carbonate*, dissolved and *injected into a vein*, weaken the cardiac contractions and render them irregular, while 60 gr. cause a sudden arrest of the circulation, the heart-muscle being paralyzed.

The corpuscles are altered by toxic doses; they cease to contain the normal quantity of oxygen, and do not absorb it even when shaken up with the gas (Feltz and Ritter).

The continued use of ammonia salts causes similar toxic effects; the pulse becomes very feeble, and the corpuscles pale and wasted, as after typhoid fever; this is but the recognized effect of all alkalies. These results are reported by Cazenave (*Bulletin de Thérapeutique*, t. xxxi.), yet Pereira has given 15 gr. thrice daily for two months without apparent injury, and often a scruple thrice daily for two or three weeks.

Ammonia or its carbonate added to blood outside the body renders it or keeps it fluid, and, when given internally, exerts an influence in the same direction; Dr. Richardson even thinks they have sometimes caused disintegration of clot already formed in the vessels (*v.* p. 259). Coagulation of blood is not, however, due to escape of ammonia, as thought probable at one time, nor will ammonia always or wholly prevent it. A difference in *time* of coagulation was the only difference observed by Rabuteau in experiments on dogs, for while coagulation of their blood usually occurs in two minutes after withdrawal, it occurred only in ten minutes when 60 gr. of ammonia carbonate had been injected: the clot, however, was firm and resistant.

Chloride of ammonium delays coagulation of blood, and when added to it with access of air renders or keeps it red, as do other chlorides.

Nervous System.—Ammonia salts, in medicinal doses, stimulate the general nervous system, probably by quickening circulation, but the special effect of large doses is exerted on the motor tract of the spinal cord, which is stimulated much in the same manner as by strychnia. Convulsions are produced, especially by strong intravenous injection, and as

these occur equally when communication with the brain is severed, they are not cerebral in origin (Lange): neither do they start in the peripheral nerves, for they take place if the blood be cut off from these nerves by ligature (Funke): we conclude them, therefore, to be of spinal origin (Pflüger's *Archiv.*, Bd. ix.), and section of the nerve-trunk of a limb stops their occurrence. Prostration follows the convulsive seizure, and a partial paralysis of the hinder limbs of animals (Rabuteau and Béhier: *Comptes Rendus*, Soc. Biol., 1873). Spiegelberg made certain experiments in order to test the opinion of Frerichs that the convulsions of albuminuria were due to the circulation of ammonia carbonate, and when he had injected as much as 6 gr. of that salt into the veins of a dog, general convulsions occurred with clonic spasm and trismus, the pupil was dilated, general sensibility was reduced, and coma set in; after an hour and a half, free salivation and urination took place, and the animal recovered, remaining stupid for some time: larger doses caused vomiting, afterward, tetanus and coma; the vessels were found full of dark fluid blood (*Lancet*, ii., 1870). It is probable that ammonia is a direct and intense *stimulant of respiratory centres* in the medulla.

The full effects of *chloride of ammonium* are not often exemplified, but in the case of a lunatic who swallowed a large (unknown) quantity, there were vomiting, giddiness, shivering, depression, delirium, convulsion, and, later, collapse so complete as to simulate death: recovery was effected with galvanic and other powerful stimuli, and then tetanic spasms came on (C. Browne: *Lancet*, i., 1868). Temperature is raised under the physiological action of the chloride; lowered under the other salts.

Digestive System.—Ammonia and its carbonate have a direct antacid effect on the gastric secretions, and moderate doses induce a sense of warmth and stimulation at the epigastrium. More than 5 gr. is likely to irritate; 10 gr. will commonly nauseate, and 20 gr. will produce vomiting. Diarrhœa is sometimes observed from continued medicinal doses (Cazenave). Liquid ammonia, when swallowed, acts as an irritant poison, and in fatal cases has caused inflammation and erosion of the upper part of the alimentary tract: occasionally it has acted upon the larynx, and induced rapidly fatal œdema glottidis. Death has been caused by 2 dr. of the strong solution; in other cases by 1 oz. (*British Medical Journal*, i., 1878), and ½ pint (*British Medical Journal*, ii., 1878).

Secretion and Excretion.—Medicinal doses of ammonia, under favorable conditions of warmth, etc., increase most of the secretions, such as those of the skin, the kidneys, and the bronchial mucous membranes. The liq. ammoniæ acetatis has a special action on the skin and kidneys, the carbonate on the lungs, the chloride on the liver and kidneys (Stewart, Rutherford). The pulmonary secretions and the bile are also rendered more fluid—ammonium chloride especially stimulates the latter se-

cretions. The alkaline salts of ammonia are not "remote antacids," *i.e.*, they do not render the urine alkaline.

Influence on Nutrition—Urea.—Although ammonia is seldom taken long enough in medical practice to directly affect nutrition, there is evidence that its continued use will produce debilitating effects like other alkalies—as indeed might be expected from its influence on the blood. Cazenave has reported pallor, anorexia, debility, and emaciation; and Huxham, a case in which hectic, hemorrhage, and general marasmus followed upon the habitual eating of ammonia carbonate (Essay on Fevers). Prout noted a great increase in the amount of urea excreted under *citrate of ammonia*, taken for dyspepsia, and the same thing has been recorded in cases of debility with irritable bladder, and pale urine of low sp. gr. (*Medical Times*, ii., 1863). Rabuteau, however, as the result of experiments on himself in health with 75 gr. of citrate daily, found that urea was slightly diminished, and also sulphates, but that phosphates were much increased in amount. Richardson maintains that ammonia suspends oxidation, and checks formation of all downward products of albumen, and retards nutrition (*Medical Times*, i., 1862, ii., 1866). There are not many observations on this point, but according to Lange, ammonia carbonate may itself furnish, by decomposition, an additional quantity of urea.

Under the *chloride*, however, urea is distinctly increased, and oxidation of tissue rendered more active.

The iodide and bromide of ammonium exert the absorbent and sedative effects of alkaline bromides generally; if anything, they are more active and less depressing than the corresponding salts of soda and potash.

Synergists.—Diffusible stimulants, heat, and, according to Gubler, opium and iodine. Both Gull and Paget have pointed out that ammonia aids the action of iodide of potassium, and it has been asserted that 5 gr. of the latter, with 3 gr. of ammon. carb., is equivalent to 8 gr. of the iodide alone (*British Medical Journal*, i., 1874). Volatile ammonia assists also the action of anti-spasmodics, such as valerian, castor, etc. Other alkalies and bases assist its antacid power.

Antagonists—Incompatibles.—Cold, emollient drinks, quinine, tannin, interfere with the action of ammonia, and are "dynamic antidotes" (Gubler).

Incompatibles are acids and fixed alkalies, salts of iron (except the tartarated iron), calomel, lead salts, etc. Freely diluted, ammonia and its carbonate may be used as antidotes to mineral acids. Christison, Pereira, and others, consider them also antidotal to prussic acid: they certainly have dynamic effects, opposite in character to those of the acid, though they do not chemically neutralize it: they antagonize also the toxic effects of alcohol, and in some degree those of animal poisons.

THERAPEUTICAL ACTION (EXTERNAL).—*Neuralgia—Rheumatism, etc.*—The strong liquor ammoniæ has been used as a counter-irritant, or a rapid vesicant, in cases of muscular, neuralgic, and rheumatic pain, and to relieve deeper-seated inflammation, for instance, of the tonsil and fauces, by derivation to the skin. For such purposes the ammonia liniment may be rubbed in, or, if vesication be necessary, it may be secured in the course of five minutes by the strong liquor applied on lint. Dr. Waring recommends, as a simple method, to fill the lid of a wooden pill-box with circular pieces of lint to above the rim, saturate with the liquid, and invert over the part. M. Gondret introduced a vesicating ointment made with ammonia and one-fourth part lard and olive oil, and it is commonly used in France. M. Ducros advised painting the liquor over the palate and gums for relief of tic.

Falling off of the Hair.—The stimulating properties of ammonia are highly useful in promoting growth of hair when it has been thinned by debility or illness. Half an ounce of the strong liquor, with almond oil, rosemary spirit, and honey-water to about 6 oz. is a good proportion (E. Wilson).

Amenorrhœa—Pruritus.—In cases of chlorotic amenorrhœa, a stimulating vaginal injection of about 1 dr. of liq. ammoniæ to a pint of warm milk has been found useful by Dr. Ashwell, and I have frequently ordered it with advantage, the breasts being stimulated at the same time by friction with weak ammonia liniment. Dr. Dewees has recorded the cure of an obstinate case of pruritus pudendi by a similar injection.

Local Inflammations.—Lotions containing ammonium chloride are very useful in inflammatory swellings of muscles, joints, lymphatic and other glands, and sometimes in the hydroceles of children—2 dr. may be used to 4 or 6 oz. of spirit and water.

In *orchitis* and in *milk engorgements* with heat and tension of the breasts, the same application is cooling and absorbent. Guéneau de Mussy recommends for the latter cases an ointment containing 5 parts of the chloride mixed with 1 of camphor and 30 of lard, to be used frequently. It is said that threatening abscess may be aborted by the continued application of compresses wet with spirit of rosemary containing about 1 dr. of the salt to the pint, and if an abscess has formed of indolent character, such as bubo often is, it may be stimulated to heal by the injection of sal-ammoniac solution after withdrawal of some pus (Ranking, i., 1871).

Acne.—In chronic cases of acne simplex with comedones, a lotion containing the chloride with alum and sulphuret of potash is sometimes an effective resource.

Stings—Snake-Bite.—Dilute liquor ammoniæ relieves the pain that follows the stings of venomous insects, wasps, etc.; it should be freely

rubbed into the part, and given internally if there be tendency to collapse.

Professor Halford (Melbourne) has strongly advocated *intravenous injection* of ammonia in snake-bite, using 15 to 30 min. of the liquor, diluted with 3 or 4 parts of water, both as antidotal to the poison, and as a general stimulant. Many cases have recovered under this treatment, but there is yet much doubt as to how far it may be depended upon: in some of them it is probable that the bites were not of fatal character, and, when experiments were repeated with more accuracy, ammonia, even injected by Professor Halford, did not avert a fatal result (*Medical Times*, ii., 1876). It has also been found powerless against the bite of Indian snakes, which are more poisonous than those of Australia (Fayrer, Short, Brunton, Ewart): in some cases death followed even more quickly than usual after the injection (Report of Commission).

The intravenous injection of liq. ammoniæ is a subject of much importance, and one that deserves more general attention than has yet been given to it: it is not free from risk and danger, especially if the large dose of 30 min. be used, but in suitable quantity it has powerfully stimulated the heart, and revived cases apparently in articulo mortis.

Shock and Collapse from Injury, etc.—Cases of fracture and laceration accompanied with collapse and treated by ammonia-injections have been recorded by Mr. Tibbitts. In one man, 40 drops with 2 oz. of warm water were passed into one of the veins of the arm, and, after temporary arrest of breathing, a violent convulsion occurred; but, on subsidence of this, general stimulation was evident, and he rallied for several hours. In a second case, 30 drops were injected, with a somewhat similar result; in the third patient, when only 10 drops were given, pulse and respiration were at once restored, vomiting occurred, and recovery followed (*Medical Times*, ii., 1872).

Recovery, though only temporary in character, followed a similar injection given during collapse in severe *scarlet fever* (*British Medical Journal*, i., 1877), and in the same condition, occurring during *puerperal fever*, Tyler Smith injected 30 min. with 3 parts of water, and ultimate recovery followed; but two cases thus treated by Mr. Spencer Wells proved unsuccessful (*British Medical Journal*, ii., 1869).

Narcosis.—Neild injected 30 drops of ammonia on four separate occasions in a patient fatally narcotized by *chloroform;* temporary recovery occurred each time (*Medical Times*, i., 1871). In a case of *opium*-poisoning, when 40 gr. had been taken, and death was imminent, revival, though only for a time, also followed directly on ammonia-injection (*British Medical Journal*, ii., 1872). Mr. Richards has specially drawn attention to the value of ammonia-injections in *alcoholic coma*, and has shown that some of Dr. Halford's patients who had much brandy (one got a bottle and a half in three hours) were really more comatose from the alcohol

than from the bite, and hence their recovery. He remarks on the importance of a slow injection, and recommends 10-min. doses (*Lancet*, i., 1880, p. 115).

Exhaustion.—In a case where extreme exhaustion was consequent on prolonged suppuration, 15 min. were injected into a vein, and again eight hours afterward with permanent good result (*British Medical Journal*, i., 1877); some of the caustic entered the cellular tissue, and caused local sloughing, and in other cases, where injection has been made purposely into this tissue, serious ulceration and abscess have followed (*Medical Times and Lancet*, i., 1870).

Therapeutical Action (Internal).—*Exhaustion—Alcoholism, etc.*—One of the most frequent uses of ammonia, and one which it commonly serves very well given by the mouth in the ordinary manner, is to quicken the general circulation and to revive failing heart-action in cases of exhaustion and threatened syncope from almost any cause: being volatile, it diffuses and acts rapidly. The vapor of the carbonate, as disengaged from "smelling salts," is sometimes usefully given by inhalation in the same class of cases, and the vapor of liquor ammoniæ has been utilized in partial asphyxia, and in the semi-coma of drunkenness. In several extreme cases of alcoholism, wherein relapses were frequent, I have known the aromatic spirit of ammonia in drachm-doses every hour or two "steady" the patient very markedly; it has acted better than, *e.g.*, vinegar, which seemed to increase liver congestion and give only temporary relief to symptoms. The depression and dyspepsia which commonly follow excessive use of alcohol are also well treated by ammonia compounds, especially if combined with valerian: in the prostration of delirium tremens, the same remedies are very useful.

Thrombosis—Embolism.—Rapid separation of fibrine in the heart-cavities seems to occur previous to death in many acute exhausting diseases, such as pneumonia, croup, peritonitis, etc., and after prolonged or difficult parturition. Dr. B. W. Richardson states that advantage may be derived in such apparently hopeless condition from the use of liquor ammoniæ ℥x. every hour, alternately with iodide of potassium (Ranking, ii., 1872). Dr. Shepherd Fletcher (Manchester) has reported a well-marked case of embolism occurring in a puerperal woman and recovering under 5-gr. doses of ammonia carbonate given every hour (*British Medical Journal*, i., 1864), and Dr. Philipson has recorded another illustration of the same character (*British Medical Journal*, 1865). More recently, Dr. Richardson has written to point out distinctive signs of the separation of fibrinous coagula in the large thoracic vessels—*e.g.*, dyspnœa with open air-passages, fulness of the neck-veins, feeble pulse with tumultuous heart-action, and weakened first sound: for such conditions he strongly advises the persistent administration of ammonia, not so much as a stimulant, but as a solvent of blood-clot, and preventive of putrefaction (*Lancet*,

i., 1875). I cannot, however, yet adopt so sanguine a view of this medication (*v.* p. 254).

Pyrexia.—In acute pyrexial and inflammatory conditions, solutions of acetate and citrate of ammonia relieve many of the symptoms by promoting secretion from the skin and kidneys.

Typhus and Typhoid Fever.—In adynamic stages of these fevers, ammonia has often been used but not always with advantage; thus Stillé reports its failure, though largely given during an epidemic of typhus at Philadelphia. There is reason to believe that the amount of ammonia circulating in the blood is unduly increased in these maladies, and this would be a reason against using it: certainly its administration is very distasteful to the patients.

Scarlatina.—On the other hand, there is much clinical evidence of the value of ammonia in this fever. De Witt, Peart (1802), Wilkinson, and Strahl have written specially in its praise, and many illustrations of its value have been given by Hillier, Camden, Graham, Sisson, Langdon Down, and others (*Lancet*, 1860, 1864, 1870; *Medical Times*, 1858, 1862, 1873, and "London Hospital Reports," vol. i.). From 3 to 6 gr. of carbonate, freely diluted, are to be given every one or two hours, until improvement occurs: it determines to the skin, and perhaps thus hastens elimination of the poison. I have found it especially useful in cases accompanied by malignant sore throat. Dr. Down refers to 192 cases occurring in one epidemic at Earlswood Asylum; 78 had severe angina, and 49 were malignant cases: all received 5 gr. of the carbonate every four hours, and were otherwise treated alike: alcoholic stimulants were used in moderation. Ten only died, and of these seven were tuberculous, and considering the low resisting power of imbeciles this result is good. He considered the remedy diminished febrile excitement and calmed the nervous system: it was taken readily without pain to the throat.

Chest Diseases.—In acute stages of pneumonia, bronchitis, or pleurisy, the acetate or citrate of ammonia is often serviceable. In asthenic cases, the later chronic conditions of bronchitis, and in senile catarrh, the carbonate and liquor are good stimulant expectorants, being eliminated in part by the pulmonary membrane, they modify its condition and thin the secretion. Ammonium chloride is also valuable in such conditions, and in asthenic lung-congestions: it may at first increase pyrexia, but generally facilitates the expectoration, "softens the cough," and improves appetite. Dr. Patton has written to commend the carbonate in acute pneumonia, and the chloride in later stages (*Practitioner*, vol. vi.).

In the bronchitis of measles, and of rachitis, ammonia is commonly and advantageously used,—Sir W. Jenner, indeed, speaks of it as *the* remedy in the lung-affections of the latter malady, which are generally asthenic and tend to collapse (*Medical Times*, i., 1860). On the other hand, Dr. Eustace Smith maintains that if too early given to children with

bronchitis it may determine even a fatal issue (*Medical Times*, i., 1873).

Croup.—In the later stages, when the membrane is more or less loosened, and perhaps capillary bronchitis is present, carbonate of ammonia may prove a useful stimulant expectorant or emetic.

Pertussis.—I have seen relief given to the cough in later stages by inhalation of ammonia vapor, and Mr. Grantham has devised a simple method of effecting this by adding 1 oz. of the liquor to 1 gallon of boiling water in a bucket or bath, and then putting in a red-hot brick (*British Medical Journal*, ii., 1871). The atmosphere of gas-works has often relieved chronic cases, a good effect which has been traced to the volatile sulphide of ammonium.

Bronchial Catarrh—Hoarseness.—The chloride of ammonium in vapor deserves trial in obstinate cases of this kind, and Dr. H. Beigel introduced an arrangement of three bottles, one containing liquor ammonia, another hydrochloric acid, and a third "wash-bottle" with water, through which air impregnated with the vapor was drawn for inhalation (*Lancet*, ii., 1867): it has not come into general use. Liebermann has suggested another form of apparatus for inhaling it (*Bulletin de Thérapeutique*, 1873).

The bromide is of service in capillary bronchitis (Bartholow), in pertussis, and other spasmodic coughs.

The chloride in lozenge and vapor has also been advised for hoarseness and granular sore throat, but the stimulus at first sometimes aggravates the symptoms.

Nerve Diseases—Migraine.—The acetate of ammonia in 1 to 2-dr. doses will often relieve sick-headache. The chloride, in 10 to 20-gr. doses, is indicated in bilious and nervous forms occurring in the young, and in delicate over-worked women,—"it stimulates the sensory nerves, and regulates the vaso-motors" (Anstie: *Practitioner*, vol. i.).

In headache connected with menorrhagia it is said to be more useful than in that connected with irregular or suppressed menstruation (Barallier: *Bulletin de Thérapeutique*, 1859).

Neuralgia.—In true neuralgia, the chloride is often of great value, as Dr. Clifford Allbutt states after observation of fifty cases (*Medico-Chirurgical Review*, January, 1872): it is, however, very nauseous to some patients.

In tic-douloureux, or facial neuralgia, especially if there be a marked rheumatic element and the lower jaw be affected, ½-dr. doses of chloride should be given at short intervals, for four doses: relief will probably have then set in if this remedy is going to benefit (Watson: "Lectures," vol. i.). In cases accompanied with heat and swelling, Brenchley recorded marked relief to pain and lowering of temperature under this treatment (Ranking, ii., 1858).

In *hemicrania* from nerve-prostration it is often curative (*Medical Times*, i., 1875), and in *sciatica* I have found either carbonate or chloride valuable, more or less permanently when the pain is worst when the patient is in the standing or sitting posture. In *intercostal* neuralgia, in anæmic or suckling women, in *hepatalgia*, and in *ovarian* neuralgia, Dr. Anstie also reported much benefit from the chloride; and of the latter malady Dr. W. Curran has reported six severe cases marked by acute pain, pyrexia, vomiting, etc., occurring mostly at a period, and accompanied with fulness over the region of the ovary, all much relieved by the chloride in 15-gr. doses, which were given, however, with 5 min. of aconite (Ranking, ii., 1868).

Dysmenorrhœa.—The acetate of ammonia will often relieve the pain of congestive dysmenorrhœa. I have frequently prescribed it with success, especially if there be a sub-inflammatory or turgescent state of mucous membrane, or when suppression has occurred from cold, shock, or fatigue (*British Medical Journal*, i., 1878, etc.).

Uterine Disorder, etc.—The chloride has often produced good results in amenorrhœa (Cholmeley: *Practitioner*, vol. ii.), and Dr. Anstie advised it in cases marked by general feebleness rather than by anæmia. Dr. Atlee states that the salt has in his practice caused the diminution of fibroid tumors (*British Medical Journal*, i., 1868). This observation may be compared with that of Dr. Rae, who asserts that the same salt is valuable in goître and glandular enlargements (Ranking, ii., 1858), but there is not much evidence on these points.

Myalgia.—For this variety of pain, Dr. Anstie affirms "nothing in the whole list of remedies comes near the chloride in efficiency," and H. Jones speaks of its power in muscular rheumatism "as remarkable and positive" (*Lancet*, ii., 1859).

Hysteria.—Ammonia relieves several of the symptoms of this disorder, such as the lassitude and tendency to fainting, and the flatulent distension of the stomach. The aromatic spirit is a good preparation in common use. The liquor with asafœtida or valerian is still more effective, but nauseous; it has some power in staying convulsive attacks of hysterical character.

Dyspepsia—Acidity, etc.—In cases where flatulence with acidity are marked symptoms, ammonia will relieve by its alkalinity and by stimulating the stomach to contract and expel flatus; it is usefully combined with other remedies—the carbonate or aromatic spirit with soda or bitters. The chloride with hydrochloric acid relieves in some cases when the tongue is furred and the biliary secretion deficient (*British Medical Journal*, i., 1875). For gastric and intestinal catarrh also, it is commonly given in Germany—not so in England.

Hepatic Disorders.—In various forms of hepatic disorder accompanied with congestion, ammonium chloride is a valuable remedy, perhaps not

yet sufficiently known in this country. Dr. Murchison recommended it in "functional liver-disorder" accompanied with lithæmia, and Dr. Anstie in suppression of biliary secretion consequent on nerve-shock. It is much used abroad in catarrh of the bile-ducts, and in the jaundice dependent on this condition; also in hepatic dropsy; but perhaps its best effects are seen in passive hepatic congestion when there is deficient intestinal secretion with loaded urine, constipation, coated tongue, and general "bilious" condition. As already stated, the chloride stimulates a due secretion of bile and increases the excretion of urea. Dr. Stewart, of the Indian service, has especially drawn attention to the value of this remedy in *hepatitis*, and even *hepatic abscess*, and has found it act better in acute than in chronic stages of these maladies. If the skin be dry, he orders first the acetate of ammonia and afterward 20 gr. of chloride every four or six hours: a feeling of warmth and exhilaration is produced, hepatic pain is quickly and markedly relieved, perspiration and urine are freely secreted, and sleep commonly follows (*Lancet*, 1870; *British Medical Journal*, ii., 1878).

Hemorrhage.—In hemorrhage of different kinds, usually passive in character, the chloride is praised by Copland, who gave it with hydrochloric acid. It is not much used, but Warburton Begbie has seen good results from doses of 20 gr. in hæmaturia: in the illustrative case recorded by him, there was no definite cause for the malady (*Lancet*, ii., 1875).

Urinary Disorder.—In acute *albuminuria*, the liquor ammoniæ acetatis is often useful, as first noticed by Addison (*Lancet*, ii., 1855), and in *diabetes*, Barlow, Golding-Bird, and Bouchardat specially valued the carbonate as being a stimulant and a nitrogenous substance (*Guy's Reports*, vol. v., etc.). Basham recommended the phosphate to be given with the carbonate and lemon-juice (*British Medical Journal*, i., 1869). Prout also thought the citrate serviceable, but rather as a diaphoretic than as possessing specific powers. The sulphide has been recommended to lessen morbid appetite in diabetes, but it does not diminish the excretion of sugar (Garrod), and ammoniacal salts have not retained their reputation in this serious malady.

In *Vesical Catarrh and Prostatitis*, the chloride has proved useful, and in a case of irritable bladder, with pale urine of low sp. gr., and deficient in urea, much relief was apparently given by the citrate; the excretion of urea was at once increased under its use (*Medical Times*, ii., 1863). The benzoate of ammonia is valuable in chronic catarrhal cystitis, with phosphatic deposit; also in scarlatinal dropsy (*Lancet*, ii., 1861, Garrod: *Medical Times*, 1864).

Preparations and Dose.—*Liquor ammoniæ fortior:* dose, 3 to 10 min. well diluted, but seldom used internally. *Liquor ammoniæ:* dose, 10 to 30 min. well diluted. *Spiritus ammoniæ fœtidus* (with asafœtida): dose, 30 to 60 min. *Ammoniæ carbonas:* dose, 3 to 10 gr. or more as a

stimulant; 30 gr. as an emetic. *Spiritus ammoniæ aromaticus* (sal-volatile); dose, 15 to 60 min. *Ammonii chloridum* (sal-ammoniac): dose, 5 to 20 gr. or more. *Ammonii bromidum:* dose, 2 to 20 gr. *Ammonii iodidum* (not officinal): dose, 1 gr. and upwards. *Liquor ammoniæ acetatis* (spirit of Mindererus): dose, 2 to 6 dr. diluted freely. *Liquor ammoniæ citratis:* dose, 2 to 6 dr. *Ammoniæ benzoas:* dose, 10 to 20 gr. *Ammoniæ sulphidum* (in solution): dose, 3 min. and upwards (seldom used: dangerous if incautiously given). *Ammoniæ nitras:* used only for making nitrous oxide. *Ammoniæ phosphas:* dose, 5 to 20 gr. freely diluted. *Linimentum ammoniæ* (with olive oil), for external use. *Compound camphor liniment* also contains ammonia solution.

[PREPARATIONS, U. S. P.—*Aqua ammoniæ*, sp. gr. 0.960; *Aqua ammoniæ fortior*, sp. gr. 0.900; *Linimentum ammoniæ:* water of ammonia 1 fluidounce, olive oil 2 troyounces; *Spiritus ammoniæ; Spiritus ammoniæ aromaticus; Liquor ammonii acetatis; Ammonii benzoas; Ammonii bromidum; Ammonii carbonas; Ammonii chloridum; Ammonii chloridum purificatum; Ammonii iodidum; Ammonii nitras; Ammonii sulphas*—used in preparations; *Ammonii valerianas*, dose, 2 to 8 grains.]

METALLIC PREPARATIONS.

ALUMINIUM Al,=27·5.

This metal has not been found native, but *alumina*, its oxide, Al_2O_3 (known also as argillaceous earth), is widely diffused as a silicate in clay, slate, granite, etc., and occurs nearly pure in the sapphire and ruby. The metal itself is of steel-gray color and is not readily oxidized: sp. gr. 2·67.

Alumen, the officinal alum, $NH_4,Al,(SO_4)_2 12H_2O$, is a double sulphate of alumina and ammonia with a large amount of water of crystallization: it occurs native sometimes in mineral waters, and in efflorescence on stone. (There are many similar "alums," or double sulphates of an alkaline base, and a metal: thus there is a potash-alum—formerly officinal, but more expensive than ammonia-alum—a soda-alum, etc. The same name is applied even when no alumina is present, as to the double sulphate of iron and ammonia—iron-alum—and to similar compounds of manganese and chromium.)

Preparation.—The officinal alum is prepared by oxidation of aluminous schist, sulphates of alumina and iron being formed then dissolved in water, and treated by sulphate of ammonia: on concentrating the solution, alum crystallizes out.

Characters and Tests.—Alum crystallizes in octahedral, sometimes in cubic, forms, but is generally met with in irregular lumps, translucent and colorless when fresh, efflorescent and covered with small crystals after exposure. It has an acid reaction and a strongly astringent, subacid taste; is insoluble in alcohol, soluble in eighteen parts of cold, and half its weight of boiling water. Heated, it dissolves in its water of crystallization, and when this has been driven off, alum remains as a dry, white, spongy mass (*alumen exsiccatum* vel *ustum*—dried, or burnt alum). This has very astringent, somewhat caustic properties; it readily absorbs moisture, but is sparingly soluble: heated beyond 400° F. it is decomposed, and alumina, the oxide, Al_2O_3, remains. This oxide is insoluble in water, and when alum solutions are decomposed, separates as precipitate; hence the use of alum for clearing turbid water, for when it is added, the alkaline and earthy salts present in the water combine with the sulphuric acid of the

alum, and the alumina which precipitates, carries with it most of the impurities present: it has also special disinfecting powers.

The *acetate* of alumina (argilla acetica), the *chloride* (aluminium chloratum), and the *single sulphate* (argilla sulphurica), though not officinal, are in occasional use; they are all soluble salts, of characteristic styptic taste. The sulphate has been found native, though not quite pure; it is more acid than the ordinary double sulphate, so that it blunts steel instruments and corrodes linen.

1. The bisulphide of ammonium (NH_4HS), when added to solution of the salts of aluminium hydrate, gives a white gelatinous precipitate of ammonium hydrate. 2. The caustic alkalies and their carbonates give a white precipitate with aluminous solutions, soluble in excess of the former. 3. Solutions of the aluminous salts should not give a blue color on the addition of ferrocyanide and ferricyanide of potassium, showing freedom from iron. 4. Alum, when heated with caustic soda or potash, evolves ammonia.

Absorption and Elimination.—Taken into the mouth alum exerts the local action presently to be described, and its first sweetish taste is followed by a peculiar feeling of constriction, and abundant flow of saliva: after reaching the stomach, combined, more or less, with albumen, some of it becomes absorbed though slowly. Orfila detected it in the urine and viscera of dogs after large doses (*Annales d'Hygiène pub.*, i., 235—9,v.), and Krauss found the urine become very acid under its use. The greater part of the alum taken combines to form insoluble compounds with the bile and other organic products, and is eliminated with the fæces. It is remarkable, that although alumina is so common a constituent of vegetable food, it is not found in the human organism, showing how completely it passes out.

Physiological Action (External).—Alum acts as a typical simple astringent, contracting the arterioles and muscular fibres of the part touched by it, and rendering the surface pale and dry. It combines with albuminous secretions forming whitish flakes, or membranous films, insoluble in water, but soluble in acetic and hydrochloric acids (Mitscherlich). If there be not enough fluid present to saturate the alum, it affects the deeper tissues in a somewhat caustic manner: this is especially the case with the dried salt. Strong or long-continued applications excite irritation with some degree of inflammation, and, under such circumstances, discharge from an affected part—*e.g.*, the conjunctiva, or the vaginal mucous membrane—may be increased rather than diminished.

The *acetate of alumina* and *chlor-aluminium* have marked disinfectant powers, preserving organic tissue, and hindering putrefaction. Burow (1857) found that the acetate, mixed with fresh blood, formed a brown syrupy mass, in which the shape of the corpuscles was not retained, but which remained, without decomposing, for many months. Albumen,

treated with the same salt, continued clear, and did not coagulate much on boiling: 0.5 per cent. prevented putrefaction of urine and of meat, and 2 per cent. sterilized bacteria.

The *chloride of aluminium*, chlor-alum, was introduced (mainly by Mr. John Gamgee) as a disinfectant free from poisonous or corrosive properties; it not only prevents decomposition, but removes its products by absorbing gas, etc.: it serves best, perhaps, for the disinfection of closets, drains, etc.: in the post-mortem room it is useful, but locally applied renders the muscular tissue pale (Lund: *Medical Times*, 1873).

Physiological Action (Internal).—*Digestive System.*—Small doses (3 gr.) taken several times daily, in water, cause dryness of mouth and throat, thirst, and diminished secretion in the alimentary canal, the stools being rendered harder and less colored than normal (Wibmer). Doses of 10 gr. disorder the digestion by lessening the gastric secretion, and from 15 to 60 gr. cause cramping pain and nausea (Barthez): 2 to 3 dr. induce vomiting without much straining, and larger continued doses may cause colic and diarrhœa with considerable *increase* of secretion from the intestinal mucous membrane.

In *rabbits*, which do not vomit, 2 dr. proved fatal, with evidence of inflammation and erosion of the stomach (Mitscherlich). To *dogs*, Orfila gave 1 to 2 oz. without other marked effect than vomiting, though if a ligature were passed round the œsophagus, 1 oz. would cause death in a few hours (Devergie). In these cases the gastric membrane was found to be either white and wrinkled, almost tanned, or was distinctly inflamed in patches.

Devergie concluded from his experiments that the human was more sensitive than the canine stomach, and certainly large doses of 1 to 2 oz. cause in man much burning pain, frothing at mouth, vomiting, purging and depression: the symptoms of gastro-enteritis may develop themselves, but usually the emetic action gets rid of the drug before serious injury is produced. The results vary somewhat with the condition of the stomach at the time, for at a trial in Paris it was proved that a lady, the subject of chronic dyspepsia, took about 20 gr. of burnt alum (by mistake for gum arabic), and suffered from enteritis in consequence. Orfila gave evidence that such a result was due to exceptional causes, and that 4 to 6 dr. were often given without inconvenience. More recently, death has been reported in a man aged fifty-seven from taking 13 dr. of burnt alum: he suffered from a sensation of burning and constriction, general malaise and anguish, hurried respiration, and nausea with sanguineous vomiting: intelligence remained good (*Union Medicale*, No. 64, 1873).

Alum was at one time largely, and even now is to some extent used in the adulteration of bread, for it gives a whiter color to the flour. Injurious effects, such as dyspepsia and constipation, have been attributed to it, and though Christison failed to notice bad results from any amount

that came under his notice, I have myself often traced indigestion to alum in the bread: it would certainly follow the use of any large quantity. (It may be noted that ordinary natural wheat flour would give about 4 gr. of silicate of alumina to the 4-lb. loaf, and the determination of the amount of added alum has been a frequent puzzle to analysts.—*Medical Times*, ii., 1875.)

Theory of Action.—We are not yet able to explain exactly the manner in which alum produces its effects, though doubtless its affinity for water, and its power of coagulating albumen, are important factors. M. Mialhe supposed the astringent action to depend upon a chemical decomposition, viz., the precipitation of alumina by the alkaline elements of secretions, or of blood; and he further supposed that the *secondary* effect of increased discharge—which we have mentioned—was due to an absorption of the recently-formed alumina rendering the blood more fluid (*v.* Stille, vol. i.). This chemical explanation is not, however, satisfactory, for taking only the latter point, astringent effects persist, as a rule, after the absorption of any ordinary doses, and it is only under the continuance of large doses (1 to 2 oz.), irritative by their mere mechanical effects, that discharge is increased; such increase, therefore, is better explained as a consequence of direct local irritation than of fluidity of blood. It is not uncommon for astringents—nitrate of silver, for example—in dilute solution to lessen discharge, and when more concentrated to increase it.

Synergists.—Tannin, sulphuric acid, and astringents generally, favor the action of alum, and are often combined with it; but as tannin decomposes alum, it seems probable that if given in the same mixture or compound, the substances may really prove less astringent than when given separately.

Antagonists—Incompatibles.—If an over-dose of alum be taken, mucilaginous and albuminous liquids, such as milk with white of egg, or gum arabic, or fluid glue, should be freely given. Magnesia should be added, according to v. Hasselt, or carbonate of ammonia in small quantities (Taylor). Alkalies and their carbonates, and acetate of lead, are chemically incompatible with alum.

Therapeutical Action (External).—Alum is one of the oldest known remedies, and was often prescribed by Hippocrates and Celsus: its properties, as already described, render it unsuitable for the acute stages of any active inflammation, but most useful in many chronic catarrhal conditions, and relaxed states of mucous membrane.

Skin Diseases, etc.—In some forms of discharging skin disease, such as chronic eczema, an alum lotion of moderate strength (1 dr. to 6 or 8 oz.) will act favorably as an astringent; it is also useful if sponged over the surface in profuse or exhausting perspirations. On indolent sores and fungous granulations the powder may be sprinkled, opium being added, if desirable, to lessen the pain that may be caused: this combina-

tion, combined with catechu, has also been praised in hospital gangrene. The "lapis divinus," which is prepared with equal parts of alum, blue stone, and nitre, fused together, is a stimulant application to ulcerated and discharging surfaces, much used on the Continent, and compounds of alumina have lately proved very serviceable as disinfectant and alterative dressings.

The acetate of alumina, and the double sulphate of alumina and zinc, have been specially recommended in lotion for fœtid perspiration and ulceration. Thorey prescribed the chloride for diphtheritic and gangrenous sores, though others report it unduly irritating.

For *antiseptic surgery* Professor Maas and Dr. Pinner have recently reported favorably, after extensive trial, of alumina acetate (*Berlin. Klin. Woch.*, 12–13, 1880, and *Medical Times*, i., 1880). Since the salt is not stable as a solid, they make a solution of 1,000 parts of "colloidal alumina" in 800 parts of dilute acetic acid (thus giving a proportion of about 15 per cent.) for preparing an antiseptic gauze, which is cheaper than, and quite as efficient as, the carbolic. For the spray, a strength of 2½ per cent. is chosen; this is strong enough to lessen hemorrhage, and does not anæsthetize the hands: for washing the skin and the instruments, carbolic solutions are still retained.

Stomatitis, etc.—When small ulcerations occur in the buccal mucous membrane, and when there is gingivitis or sponginess and inflammation of the gums, dried alum, applied in the form of powder, or a lotion containing it with myrrh and spirits of wine, is very useful. Salivation is also restrained by its moderate use, and injurious effects on the gums during a mercurial course may be prevented by keeping a piece of alum in the mouth for a few minutes occasionally. At Aix-la-Chapelle, patients are ordered to use alum gargles and washes frequently during the mercurial treatment.

Toothache dependent on caries may often be cured by the local use of a paste made with alum, ether, and mucilage, which should be applied until the sensitive nerve is destroyed (Legaulon).

In *Catarrhal Angina* and "relaxed throat," especially for relaxed uvula, the gargle of Rivière (1 dr. of alum to 6 oz. of water) is still a frequent prescription. It is said, however, to be injurious to the teeth, and plain water should be used after it.

In *Hoarseness*, a gargle containing 2 dr. of alum in 6 oz. of barley water has been found useful for professional singers (Bennati): the remedy is still better applied in the form of spray (10 gr. to 1 oz.).

Tonsillitis.—In early stages even of acute tonsillitis, insufflation of very finely-powdered alum, or warm, weak alum gargles will often assist in cutting short the attack, but if this be fully developed before treatment is commenced, alum would be more likely to irritate than to relieve: its use is better reserved for chronic congested conditions, with or with-

out spots of ulceration, when the fine powder should be gently blown over the affected part through a quill or suitable tube.

In *Purulent Ophthalmia*, as occurring especially in children, an alum lotion containing 4 to 6 gr. to the ounce is very useful when properly applied: it should be used very frequently, every half-hour or hour, in a gentle stream, so as to thoroughly cleanse the lids, and in addition drops of a weak solution of nitrate of silver may be required once daily: this method is the most relied upon at the London Ophthalmic Hospital (*Medical Times*, ii., 1873).

In *Gonorrhœal Ophthalmia*, and in the severe ophthalmiæ of Egypt and India, similar frequent use of alum lotions is also serviceable. My colleague, Mr. Macnamara, has seen cases cured in the latter country by applying round the orbit a mixture of burnt alum with lemon-juice.

In *Catarrhal Conjunctivitis* and *Chemosis*, a convenient and useful application is the alum curd, made with boiling milk, or the alum "poultice," prepared by rubbing a little of the powder with white of egg till a coagulum is formed; this is placed between two layers of thin cambric and applied over the closed lids.

Otorrhœa—Ozæna.—In sub-acute or chronic stages of otorrhœa, an alum-injection of the strength already mentioned—4 to 6 gr. to the ounce—is cheap, and often effective: its use should be preceded by a douche of plain water, otherwise the alum will be prevented by coagulated secretion from directly reaching the affected membrane. The remedy should not be continued too long, or it may excite irritation.

In chronic ozæna (offensive nasal discharges), a douche of double or treble strength may be used. Homolle has recommended the *single sulphate* as a better remedy for this disorder, and others have preferred the chloride (chloralum) or acetate.

Nasal Polypi have sometimes been cured, or greatly relieved by the insufflation of finely powdered alum, or strong alum solution.

Leucorrhœa—Gonorrhœa.—Injections of alum alone, or combined with zinc or oak-bark, are often used with advantage, especially in leucorrhœal discharges: a strength of about 5 gr. to the ounce is usually sufficient, and plain water should be first injected to cleanse the surface. In the early acute stages, as already mentioned, alum is not suitable, and at any time, too strong a solution applied to the vagina may cause irritation and cramping pain.

Prolapsus.—Leucorrhœa is commonly accompanied by a relaxed condition of vaginal mucous membrane, which is also amenable to alum. A good method of using it is to place a sponge, soaked in its solution, well within the vagina for several hours; this will often relieve the slighter forms of prolapsus uteri. Rectal prolapsus should be bathed with alum water before being returned, and afterward an injection of the same should be practised.

The severe *Pruritus* and burning about the vulva and the anus, often associated with leucorrhœa and prolapsus, may be equally relieved by strong alum solutions.

In the *Vulvitis* of children, Dr. Ringer regards alum as one of the best remedies, recommending a solution of 1 dr. to the pint of water, to be applied constantly, and injected occasionally.

Excoriations of Cervix Uteri.—The local application of alum was, at one time, much praised in this condition (Delmas: *British and Foreign Review*, July, 1841).

Chronic Catarrhal Cystitis.—This obstinate disorder may be often relieved by the use of a weak alum-injection—10 gr. in the pint: the bladder should be first washed out with warm water, so as to avoid the clotting of discharge.

I have known vesical pain and frequency of micturition quickly relieved by such injections, which have been followed also, in several instances, by marked diminution of the thick, gelatinous, ropy mucus commonly secreted in this malady: the alkaline reaction and acrid ammoniacal odor of urine have been removed at the same time. The last-named conditions may be dependent sometimes on the introduction of low organisms by a soiled catheter (Traube, Niemeyer), but even in such cases, alum-injections are equally useful by their antiseptic properties. Blockley and Parkington specially recommended the single sulphate for vesical and vaginal catarrh.

Hemorrhage—Epistaxis, etc.—Alum is serviceable applied externally in cases of bleeding from superficial vessels, as from the surface of wounds or mucous membranes, *e.g.*, of the nose or of the vagina, from hæmorrhoids, from leech-bites, or after tooth-extraction: in such cases it may be used in substance, a pointed plug or the fine powder being firmly pressed on the part, or a compress steeped in a strong warm solution may be allowed to cool upon it. Such applications condense the tissues and contract the vessels, but it should be borne in mind that if too strong or too prolonged, they may give rise, especially in scrofulous subjects, to unhealthy ulceration. The alum powder is sometimes combined with zinc sulphate, or diluted with starch or sugar, and the solution may be made with decoction of logwood. Combined with benzoin and alcohol, it forms a celebrated styptic and antiseptic, the "Aqua Pagliari" (benzoin, 100 gr., alcohol, ½ oz.; dissolve and add water, ½ pint; alum, 1 oz.; boil till clear, then filter). The solution of Mentel is similar, but made with the single sulphate.

Therapeutical Action (Internal).—The internal use of alum is combined with its external application in many varieties of hemorrhages, though it is not depended upon so much now as formerly: it is best suited for cases of "passive hemorrhage," with relaxed condition of mucous membrane, and when no acute inflammation is present.

In *Hæmoptysis*, tubercular or otherwise, when moderate but persistent, it is a good adjuvant to other remedies, *e.g.*, sulphuric acid. Skoda commonly gave 10-gr. doses with Dover's powder. A spray containing the same quantity in 1 oz. of water may be used with advantage at the same time.

In *Bleeding from the Stomach* or bowels—dependent as these symptoms often are upon cirrhosis, and when passive and atonic in character—alum may be a suitable remedy; its astringent effect in such cases is, in part, at least, direct and local.

In *Menorrhagia* Cullen specially commended alum, and it is still used more frequently perhaps in this flux than in any other. In the form of "alum whey," which is prepared by boiling 2 dr. of the powder with 1 pint of milk, straining off the curd, and adding sugar, it is a not unpleasant medicine, of which a wineglassful, three or four times daily, will generally control the discharge—according to my own observation.

Hæmaturia.—In bleeding from the kidneys, alum whey is also useful, but "iron alum" (double sulphate of iron and ammonia) is a still more active remedy, which has, in my experience, acted better than many others. In cases where blood comes from the mucous membrane of the bladder or urethra, and when pain, straining, and undue frequency of micturition are present, I have known speedy benefit follow the use of alum injections (20 gr. to the pint) into the bladder.

Albuminuria.—The drain of albumen in Bright's disease is practically equivalent to a loss by hemorrhage, and it has been sometimes restrained by the use of alum: thus, Oppolzer and Heller have reported benefit from it in chronic cases (quoted by Dr. W. Roberts), but after repeated trials I have not been able to verify their good results.

Diabetes.—In diabetes insipidus, or "polyuria," when there is an excessive flow of limpid but non-saccharine urine, alum deserves further trial, though the malady is anomalous and often is uncontrolled by any remedies. In true diabetes a partial and temporary benefit has been derived by some patients for whom I have prescribed it.

Gastric Catarrh.—In cases with vomiting of glairy mucus, alum is a cheap and efficient remedy. Sir J. Murray, one of the principal advocates for its use, pointed out that it acted better when given in substance than in solution: thus a pill with gentian extract is a good form, or an electuary with honey.

Diarrhœa.—I have found alum very useful in infantile diarrhœa when arising from errors in diet, and attended with vomiting, acidity, and green stools: from 1 to 5 gr. may be given with syrup. Diarrhœa dependent upon relaxed conditions of mucous membrane is also cured by alum. Fouquier and others have praised it in enteric fever (*Bulletin de Thérapeutique*, ix., p. 301), but it is not easily taken, and it is liable to irritate, so that other remedies are usually to be preferred. Alumina, or argilla

pura, is placed in the Austrian Pharmacopœia as an antacid remedy for diarrhœa, especially in children, and is used like bismuth salts. Barthez recommends the single sulphate as preferable.

Dysentery.—Moseley, in his work on tropical diseases, considers alum to be one of the best medicines in acute and chronic dysentery, and Dr. Waring has often seen it useful in asthenic cases; it was commonly given with opium. I think that a good mode of administering it in chronic cases is by injection, from 10 gr. to 2 dr. in a pint of liquid being used at a time (Hannon: *Bulletin de l'Academie*, xxxii.); this will also relieve the troublesome tenesmus, and the sense of itching and excoriation about the anus. One drachm to the pint is a proportion I have commonly used twice daily with good success: a strength of ½ oz. to the pint has also been used, but caused some burning pain; improvement, however, soon began, and cure resulted after about fourteen days of treatment (*Medical Record*, 1879).

Constipation.—Besides the astringent power exerted by 5 to 10-gr. doses of alum, we must notice the irritant effect of larger quantities, by which probably they become useful in constipation. Alum is seldom to be preferred to other remedies for this disorder, though it may act favorably in atonic cases, when the muscular coat of the bowel is deficient in power, and when mucous secretion is scanty. Mr. Aldridge has published reports illustrating the good effect of 20 to 40 gr. daily in producing copious and solid evacuations; he also associated it with sulphate of magnesia (*Braithwaite*, vol. xii.). Such treatment, however, is rarely worth trial, and my own experience with it is not favorable; it either increased constipation or caused dysenteric symptoms.

Lead Colic.—In this common and painful malady, which is always accompanied by obstinate constipation, there is much evidence of the virtue of alum, dating from the last century. Dr. Copland praises it, and M. Brachet of Lyons, writing from a large experience, awards to it the first place among remedies: for eight years he states that the treatment he employed consisted of emetics and purgatives, then he gave a trial to antiphlogistics, and then to opiates: lastly, influenced by the success of Gendrin, he commenced to give 1½ to 2 dr. of alum daily in mucilaginous liquid, and either with or without laudanum; on the third day usually the bowels acted, and if not, an aperient was given and the patient was nearly or quite cured, and this in upward of 150 cases. The successful cases of M. Gendrin were fifty-eight in number, and he experienced no failures with the alum treatment.

In considering how it may operate, it is curious to notice the different views that have prevailed as to the pathology of the malady. M. Baumés, Mialhe, and others, consider it a general poisoning of the system; Combalusier limits the poisoning to the primæ viæ; Cullen, Vogel, and others, make the colic a nervous affection, Willis refers it to the brain, Serre to

the spinal cord; Orfila and Grisolle consider it a lesion of the abdominal nerves, or the great sympathetic, while Bracher and Andral trace it to lesion both of cerebro-spinal and ganglionic nerve-centres.

The intestines have been most generally regarded as the seat of disease, either in all their structure or in their mucous or their muscular coat. Méral especially argues that the latter is in a state of paralysis, a conclusion which has been widely accepted, and alum has been supposed to act partly as a stimulant to the paralysed muscle, and partly as a direct chemical antidote to the lead which it converts into an insoluble sulphate. In support of this view it may be mentioned that other sulphates, as of magnesia, soda, zinc, and free sulphuric acid also act favorably; but it scarcely explains the quick relief that is sometimes given, and one cannot say that its mode of action is quite clear. It would seem to have a specific power of relieving pain, because it has proved useful in other varieties of gastralgia and colic (Dr. Griffin, on Spinal Irritation, etc.).

I have myself only witnessed the good effects of the drug in two cases of lead-poisoning which presented all the usual symptoms: it relieved the pain and terminated the constipation; from 10 to 20 gr. may be given every two hours, properly diluted, and this quantity may be increased to 1 dr. or more, if necessary. Sulphuric acid and syrup of lemon form a suitable vehicle for it: in some cases it is well combined with a little opium.

On the other hand, several good authorities report less favorably of the remedy: Tanquerel and Grisolle found it almost inert, and Brown records increase of pain and of constipation from its use. Husemann, who may be taken as representing the German school, speaks of it as "obsolete," but with us it certainly is not so; Dr. Bartholow, for instance, in his recent treatise, describes it as "most effective" in the relief of the pain, the vomiting, etc.

Emetic Action— Croup.—Besides its astringent and stimulating power, alum, in doses of about 1 dr., is a very useful emetic, because it is prompt in action, and does not depress the system: hence it has been recommended in croup both to dislodge the false membrane and hinder its re-formation; it may be repeated every quarter of an hour for several doses. Narcotic poisoning has also been treated by it.

Whooping-Cough.—In the chronic stages of this complaint, where secretion is profuse and spasm severe, and there is not much complicating bronchitis or pyrexia, I have seen alum exert a very beneficial influence: 4 to 10 gr. in water or syrup should be given three or four times daily. Dr. Golding Bird introduced and highly commended this treatment, conjoining the alum with conium and dill-water. Dr. Meigs states that alum has given him, in sixty-eight cases, better results than any other remedy (Diseases of Children). Its good effect may be traced, probably, to a lo-

cal astringent action on the fauces; hence it is best administered in some thick vehicle, and swallowed slowly.

Asthma—Bronchitis.—It is said that a paroxysm of asthma may sometimes be prevented by placing about 10 gr. of alum on the tongue (Ringer). In bronchitis, 5 to 10 gr., given every four hours, serve to facilitate expectoration, and at the same time its amount is restrained and dyspnœa relieved. Moseley praised this use of alum many years ago, and advised it both for acute and chronic forms with viscid ropy expectoration; but it is in these latter cases only that I should consider it suitable.

Preparations and Dose.—*Alumen:* dose as an *astringent*, 10 to 20 gr.; as a *purgative*, 30 to 60 gr. or upwards; as an *emetic*, 1 dr. to 1 oz. In lead colic, 20 to 120 gr. have been given in the twenty-four hours. *Alumen exsiccatum:* the dose should be somewhat less, and practically this preparation should be kept for external use only. The *solid drug* seems to be more effectual than the liquid form; it may be given in pill or in confection with sugar, honey, or molasses: cream of tartar may be added, if necessary, to obviate constipation, and cinnamon or other aromatics to prevent flatulence. The "*Pills of Helvetius*," formerly celebrated, contained 3 gr. mixed with "dragon's blood;" a more modern formula is with gentian, rhubarb, etc.

In *solution* it may be given with sweetened aromatic water or mucilage, or sulphuric acid and syrup of lemons may be added; or an "alum whey" may be made by stirring 2 dr. of the powder with a pint of boiling milk, straining, and adding sugar.

For a *collyrium*, a strength of 5 gr. to the ounce of rose water is suitable: for a *gargle* from 8 to 20 gr. in the ounce: for a *lotion* or *injection* it may be well combined with zinc sulphate, as in the liq. aluminis co. (L. P.), which was ordered with 1 oz. of each salt to 3 pints hot water. *Ointment:* 12 to 24 gr. to the ounce of simple ointment. *Liniment:* with white of egg and camphorated spirit (for bedsore).

[Preparations, U. S. P.—*Alumen*—Same as that of the Br. Pharmacopœia; *Aluminii et potassii sulphas*, the common alum of the shops; *Aluminii sulphas.*]

ANTIMONIUM—ANTIMONY—STIBIUM, Sb,=122.

This substance, which is now classed among metalloids, occurs native, but in small quantities. It is usually found in alloy with various metals, chiefly iron, lead, and arsenic, and from these its purest commercial samples are seldom quite free. Traces of it occur also in some chalybeate waters, and its oxide constitutes the "white antimony ore" (valentinite): its most common ore is the sulphide, from which crude antimony is obtained by fusion with iron, or by roasting and reduction with charcoal.

When pure, it is silvery white in color with a tinge of blue, laminated in structure, brittle, and crystalline; it is heavy (sp. gr. 6.7) and permanent in the air at ordinary temperature. In its chemical relations it is allied to nitrogen and phosphorus, and still more closely to arsenic.

Compounds of Antimony.

ANTIMONIUM NIGRUM—BLACK ANTIMONY, Sb_2S_3, =340.

Preparation.—From the native ore stibnite, by fusing and then reducing to a fine powder.

Characters and Tests.—A crystalline steel-gray metallic-looking powder, which dissolves in boiling hydrochloric acid, with evolution of sulphuretted hydrogen.

ANTIMONIUM SULPHURATUM—SULPHURATED ANTIMONY, Sb_2S_3, Sb_2O_3.

(Golden or precipitated sulphuret, an oxy-sulphide).

Preparation.—By dissolving the black sulphide in caustic soda with the aid of heat, and adding sulphuric acid; several complex reactions occur, and sulphurated antimony is precipitated.

Characters and Tests.—An orange-red powder, inodorous, almost tasteless, insoluble in water, soluble in hydrochloric acid, also in solutions of caustic alkali, and of acid tartrate of potash: exposed to light and air it partially decomposes, with separation of sulphur.

There are several other reddish or brown oxy-sulphides of antimony, and all have been termed "kermes mineral," from some resemblance in color to the insect kermes (cochineal).

ANTIMONII CHLORIDI LIQUOR—SOLUTION OF CHLORIDE OF ANTIMONY, $SbCl_3$, =228.5.

Preparation.—By dissolving black antimony in hydrochloric acid.

Characters and Tests.—A heavy, yellowish-red liquid, which, when poured into water, gives a dense white precipitate of oxy-chloride (SbOCl).

The pure chloride, which may be obtained by distillation, is volatile, but concretes, on cooling, into a soft, white solid, "*butter of antimony;*" and this term is sometimes given to the officinal solution.

ANTIMONII OXIDUM—OXIDE OF ANTIMONY, Sb_2O_3, =292.

Preparation.—By decomposing the oxy-chloride with sodic carbonate.

Characters and Tests.—A grayish-white powder, inodorous, taste-

less, and insoluble in water, soluble in hydrochloric acid: moderately heated, it turns yellow, at a red heat it burns, or sublimes in crystals.

ANTIMONIUM TARTARATUM—TARTARATED ANTIMONY—TARTRATE OF ANTIMONY AND POTASH—TARTAR EMETIC, $KSbC_4H_4O_7H_2O$, = 343.

PREPARATION.—By mixing the oxide of antimony with acid tartrate of potash and water for twenty-four hours, afterward boiling in water, and crystallizing out.

CHARACTERS AND TESTS.—Occurs in rhombic, octahedral, colorless crystals, transparent when fresh, but efflorescing on exposure to air; also, and more frequently, in the form of powder, which should be perfectly white, a yellowish tinge indicating the presence of iron. It is odorless, but has a sweetish, subacid taste, which quickly becomes metallic and nauseous, but may not be much noticed if the powder be largely diluted. The crystals are best obtained for microscopic examination by evaporating on a slide a drop of the hot solution: characteristic triangular facets are seen, and some modifications of the cube, and they are larger than *arsenical* crystals: branched crystalline forms also occur, as in many other saline solutions. The crystals of tartar emetic are isomorphous with those of the *sulphate of potash*, but the latter do not effloresce. Tartar emetic is soluble in two parts of boiling, and in fourteen parts of cold water; less soluble in proof spirit, or in wine, and insoluble in absolute alcohol. Acids, except tartaric acid, occasion a white precipitate, as also do alkalies, alkaline earths, and their carbonates, but excess of these agents will re-dissolve the precipitates.

The dried salt, like other tartrates, decrepitates and chars on the application of heat, and its solution in water readily becomes mouldy from the development of a fungus (a little added spirit will prevent this).

Infusion of galls, catechu, cinchona, strong tea, or tannin in any form, precipitate a tannate of antimony, which is so insoluble as to be practically inert. The following tests are applicable to any soluble antimonial salt:—(1) If it be boiled in water with one-sixth part of pure hydrochloric acid and a strip of metallic copper, antimony will be deposited on the metal, violet-red in color if the quantity be small, but iron-gray, or black, if in large amount. (2) A solution acidulated with the same acid ($\frac{1}{16}$th) gives, in the cold, a black deposit on pure tin. (3) Sulphide of ammonium, or sulphuretted hydrogen, produces, in acid solutions, an orange-colored deposit soluble in hydrochloric acid (boiling), and, if this latter solution be poured into water, a white deposit of oxide occurs. (4) Evolution of nascent hydrogen (as from zinc and sulphuric acid) in the presence of antimony, leads to the formation of antimoniuretted hydrogen:

this burns with a blue flame, and produces on porcelain a black stain which is insoluble in bleaching powder.

Absorption and Elimination.—Soluble compounds of antimony, such as tartar emetic, are readily absorbed, especially by mucous membranes, and they circulate in the blood, either unchanged or as albuminates. The infant at the breast may be affected by them through the mother, and they may be detected in the different secretions during life, and in the viscera, especially the liver, kidneys, and intestines, after death.

The degree of absorption naturally varies with the preparation used, the dose, and the state of the stomach. Metallic antimony in powder, the oxide, and the sulphuret are absorbed to some extent, but much less freely than the potassio-tartrate, which is itself more completely absorbed, and acts more powerfully, if acid wines or fruits are taken at the same time (Trousseau). Large doses are usually vomited soon, and before much absorption has occurred; but if taken with, or shortly after, food vomiting is delayed, and a poisonous amount is more readily taken up into the circulation. This does not conflict with the statement made by Trousseau, that if a patient be living *well*, irritant effects, such as vomiting and purging, are more likely to occur from medicinal doses of antimony, while *spare diet* favors the production of constitutional effects, such as sedation and increased secretion, without so much gastric irritation. This fact has been explained by the presence of more chlorides in a full diet (as compared with a spare one), leading to the formation of more of the irritant chloride of antimony (Mialhe); but Bellini found that no such decomposition occurred with artificial gastric juice at the temperature of the body, and the hypothesis of Mialhe has not been accepted.

If the mucous membrane of the alimentary tract be inflamed, the irritant effects of antimony are proportionately severe.

Absorption may occur through the skin, though not readily while the epidermis is intact. After frictions with antimonial ointment vomiting has occurred, and the drug has been found in the urine (Coze: *Bulletin de Thérapeutique*, 1869).

Antimony is *eliminated* by the kidneys, the skin, by the mucous membrane of the bronchi, and (mainly) by that of the intestines, and by the intestinal glands. Orfila recorded its special determination to the lungs, and Millon to the liver (*Annales d'Hygiène*, vol. xxxvi.). An important fact is that elimination occurs by the intestinal tract, even when the drug has been given by the veins, the rectum, or any other channel (Hermann, Richardson, Brinton, and others, *Lancet*, i., 1856). The amount passed out by the kidneys, and probably by the other glands, varies at different times in the same individual, for Mayerhofer, while continuing to take the drug, found it only occasionally present in the urine (Heller's *Archives*, 1846).

The time of its remaining in the system has been variously estimated. According to Taylor, it passes wholly from the stomach within a short time, and may then be found in the liver, the kidneys, and spleen, and in smaller quantities in the blood. After a few weeks, all traces have disappeared from these tissues, but some may be found in the fat and the bones; generally, elimination is complete in from twenty to twenty-five days, but according to Millon and Lavran, the drug may be found in the liver and intestines four months after administration (loc. cit.).

Physiological Action (External).—The watery solution of tartar emetic applied to the skin acts as a slight irritant, producing redness, but the ointment when rubbed in acts more powerfully, causing inflammation and pustulation; caries of subjacent bone has even been traced to it. The pustules produced by antimony are very painful; they are irregular in size and shape, but being often umbilicated, resemble those of variola: they mature about the fifth day, forming scabs; sometimes they slough and leave scars. Individuals vary much in susceptibility to the ointment, and during fever, or severe visceral inflammation, pustulation is not easily induced.

It has been stated that alkalies mixed with antimonial salves prevent their pustulating effect, and also, but incorrectly, that freshly-blistered surfaces do not pustulate because of the alkalinity of the serum: on the other hand, acids increase the effect (M. Coze, loc. cit.).

If concentrated solutions be taken by the mouth, they are liable to cause inflammation and even aphthous ulceration about the gums, fauces, and œsophagus, so that an "antimony sore throat" has been described, and its accompanying salivation and dysphagia may be very severe. Conditions much resembling those of diphtheria have also occurred (*Medical Times*, i., 1846), but are not often met with under the present more cautious use of the drug.

The prolonged contact of antimony determines in the intestinal mucous membrane local phlegmasiæ analogous to those already described as occurring in the skin; Trousseau verified this by post-mortem examinations.

Physiological Action (Internal).—*Circulatory System.*—Under the influence of antimony, the blood is altered in its chemical characters (Richardson), but in a manner not yet well understood; it may certainly become impoverished from destruction of red, and increase of white corpuscles (Schmidt), just as under the action of arsenic (Koschlakoff): in cases of poisoning by the drug, it has been found more fluid and less coagulable than normal, the amount of fibrine being diminished.

A prominent symptom of the full action of antimony is *depression* of the circulation, both as to force and rapidity; but such depression is often preceded by a rise in the pulse-rate, and a similar rise may occur before death in the later stages of poisoning.

Ackermann, indeed, experimenting upon healthy men with emetic

doses (about ¾ gr. of the tartrate), found a *prolonged rise* in the pulse-rate, to an average maximum extent of 42 per minute, and this was distinctly related to the gastric symptoms. The rise began only with the onset of nausea, and increased with the occurrence of vomiting, after which the pulse fell to an ordinary level: it became also soft and weak in proportion to its quickness, but he did not observe any decided fall below the normal rate at any period (Abstract, *British and Foreign Review*, April, 1859).

These observations were carefully made, the pulse being examined every five minutes for several hours, but they illustrate only the effect of one or two doses. There can be little doubt that a longer course of the same, or a larger initial dose, would have induced the slowing of pulse which has been verified by so many observers; but we may note a parallel observation made by Trousseau, that in some few persons taking antimony the pulse became and continued quick, as well as weak and irregular. Usually, as at first stated, slowing of the pulse is a marked and somewhat persistent effect of antimony, and especially so when vomiting does not occur at all, or after it has ceased: from six to ten beats per minute is an average amount of decrease after doses of 1 to 2 gr., but it may vary from three beats to forty (Pécholier, Bonamy). Gubler has noted a proportion between the ultimate fall and the primary increase. (Whether such primary increase, when it occurs, is due to a temporary excitation of the whole system, or to paralysis of the regulating branches of the vagus, has been a question: the former is, I think, more probable). Arterial pressure is much diminished, and the curves of a sphygmogram may be almost effaced (Bordier): more or less venous congestion also occurs.

After very large doses, any acceleration is but slight and transient, before the blood-current becomes slow and almost imperceptible. In frogs, dogs, or rabbits, when a sufficient dose has been introduced by any channel, the cardiac contractions also soon become slower, weaker, and irregular, the auricles contracting oftener than the ventricles. When death occurs from the drug it is said to be always through cardiac palsy (Richardson), the general state of collapse being secondary to failure of the circulation. Arrest finally occurs in diastole, and the irritability of the cardiac muscle is found to be impaired or lost (Radziejewski, Bellini), probably owing to a directly paralyzing influence on the cardiac muscular structure when reached by the drug after absorption. When antimony is applied to the batrachian heart, removed from the body, similar slowing and arrest take place, which is another reason for considering the action to be directly on the muscular structure. It is curious that in animals subjected to toxic doses, death can be delayed for some hours by dividing the vagi (Majendie).

Rabuteau notes the remarkable analogy between the above action of antimony, and that of digitalis. Nobiling traced the depressant effects

described to the potash, rather than to the antimony in tartar emetic, but his observations have been disproved.

Respiratory System.—In the experiments of Ackermann, the number of respirations increased in direct relation with the increase in the pulse-rate, but, under the continued influence of the drug, independently of irritant effects, and of any preventing lung-disorder, the rate of respiration is slowed. It may be so by as much as half or two-thirds the normal rate, so that only six respirations occur per minute, and this without general distress or impairment of other functions (Trousseau).

After poisonous doses, the breathing is very irregular, at one time hurried, short, and painful, at another, extremely slow, with labored and forcible inspiration and expiration: this is due in part to paralysis of the heart and other muscles, in part to impairment of reflex sensibility and to altered conditions of the blood. After death in such cases, Majendie, finding the lungs partially congested and hepatized, concluded that the action of antimony was specially exerted on these organs, and Mayerhofer certainly proved its elimination by their mucous membrane: ecchymoses and emphysema are found when the act of breathing has been very labored.

The effect of the drug upon the excretion of carbonic acid has been differently stated: some observers report it lessened in amount (Coze, Mialhe, Rabuteau), but recent writers (Ringer, Bartholow), express an exactly opposite opinion, though neither gives his original authority (*v.* p. 283). Further accurate observations upon this point are admittedly wanting, but having regard to the sedative effects of sufficient doses, independently of inflammatory action, the former statement seems to me more in accordance with known facts. That *arsenic* lessens the excretion of carbonic acid is now recognized, and though Gubler holds that we do not know enough of arsenical action to make the analogy of scientific value, I should hesitate before ascribing to so closely an allied drug as antimony, a directly opposite effect in this important particular.

Digestive System.—Upon the alimentary tract, antimony acts as an irritant in greater or less degree, according to the dose: $\frac{1}{30}$ to $\frac{1}{15}$ gr. of the tartrate, or even less when repeated, will induce some sense of warmth in the stomach, and some increase of its secretions; $\frac{1}{8}$ to $\frac{1}{4}$ gr. will cause, in addition, a feeling of soreness, a flow of saliva, impairment of appetite, and possibly nausea; $\frac{3}{4}$ to 1 gr., given in a glass of water, will usually induce vomiting within fifteen to thirty minutes. The vomiting is distressing in character, accompanied with shivering, much depression, retching, and persistent nausea: the ejecta contain mucus, and later, bile. The same dose generally purges, and if taken with a *large quantity* of water will be almost sure to do so, either with or without vomiting. The evacuations at first are simply fluid, then mixed with free bile, and are passed with some straining and griping pain. It is noteworthy that a larger

dose is required to produce these effects when given by intravenous injection than by the stomach.

Large doses of 10 to 20 gr. or more, act very severely; the local irritation and burning pain are great; vomiting occurs quickly and with much distress; there is difficulty in swallowing, spasm of œsophagus, severe tenesmus and cramp in the abdominal muscles, and profuse diarrhœa of sero-albuminous fluid, containing flocculi of detached epithelium (like the rice-water stools of cholera), and sometimes blood.

In fatal cases the mucous membrane of the stomach and of parts of the intestine, especially the lower portions and the rectum, has been found acutely congested or inflamed, softened, aphthous, or ulcerated.

Conditions modifying the Action of Antimony—Tolerance, etc.—The preceding description requires to be qualified, especially in cases of what is called "tolerance." If the giving of antimony be commenced in fractional doses, and continued with very gradual increase, it is possible to produce full sedative effects without gastric disturbance. Again, in certain forms of illness, with altered hæmatosis, such as pneumonia, or in some nerve-disorders, as chorea or delirium tremens, full doses may be given without any evidence of irritation, and then "tolerance" of the drug is said to be established. Further, in some instances, ½-dr. and 1-dr. doses have been taken without vomiting (Hicks: *Lancet*, ii., 1876, p. 38), and in other cases of poisoning from very large doses, the prominent symptoms have been those of collapse, and the patient has died without vomiting or purging, or complaint of pain. Indeed, not the least of the difficulties in studying the action of antimony, we find in the circumstance that sometimes there is no post-mortem evidence of irritation or inflammation to be found, either in stomach or intestine (Handfield Jones, Bellini, Böcker). As with other powerful drugs, there may also exist some idiosyncrasy in certain persons, leading to difference in result that we cannot otherwise explain, but the account I have given represents the effects as usually observed: as a rule, it acts with most intensity on the delicate, on women, and more especially on children, and in these subjects "tolerance" is less easily induced than in men, and lasts for a shorter time. When tolerance has once ceased, great care must be exercised in resuming the drug, for it will more readily excite gastric derangement (Trousseau).

Glandular System.—Moderate doses increase the secretion of the parotid, the pancreas, the liver, and the gastric and intestinal glands, the drug acting as a stimulant or irritant during its elimination by these structures.

The increased secretion has been variously attributed to irritation of the gland-cells, and to paralysis of their controlling nerves: the former is the primary, the latter a secondary effect.

Cutaneous System.—Whether it has a like action on the sweat-glands

has been disputed, and the increased perspiration which commonly follows its use has been attributed to the act of vomiting, or to the course of an illness (Trousseau). It is true that when the remedy is "tolerated" there is usually little sweating, but this need imply only that under certain conditions less of the drug is excreted by the skin. In my own experience, diaphoresis has occurred clearly from antimonial action, independently of vomiting, and this seems quite in accord with the increased secretion from other glands. (I do not here refer to the profuse cold sweating of later stages of poisoning,—the result of exhaustion.)

Neither do I see any difficulty in accepting the (few) recorded cases of pustular eruption following the internal use of antimony (Gleaves, Böcker, Mayerhofer, Taylor). The drug is certainly eliminated in greater or less extent by the skin, and that it may sometimes cause suppuration is not more unlikely than in the case of iodide of potassium.

Urinary System.—There is difficulty in estimating exactly the effect of antimony on the kidneys, and statements with regard to it vary much. It is probable that more or less of the drug may be excreted by this channel, according to circumstances, for, as already stated, Mayerhofer, experimenting on himself, could, at one time, detect it in his urine, and at another time, not; he found the amount of urine at first increased, afterward lessened. Trousseau and Gubler report a marked increase in the secretion only when vomiting and purging were absent or slight, and this was the case also in Hannon's experiments.

If the circulation be extremely depressed, or if choleraic symptoms occur, the urine is likely to become scanty, or even suppressed.

Other observers distinguish between the different constituents of the urine; Böcker, taking himself 2½ gr. daily for nine days, found the urea and other urinary solids markedly lessened, and Beigel, giving a similar dose to four patients for four days, obtained the same results: in both instances, comparatively little food was taken.

Dr. Parkes, however, found the amount of urea increased after sulphuret of antimony, and several modern writers (Ringer, Bartholow) describe a similar increase, relying, probably, on the observations of Ackermann. His subjects received a cup of coffee, and then remained in bed for a day, taking from 1 to 2 gr. of tartar emetic, which caused emesis and often purgation. He reported that the water and the chlorides were diminished in proportion to the diarrhœa, but urea was increased by one-eighth, or even one-fourth, and uric acid and pigment were also increased: these results he attributed to increased metamorphosis. I cannot, however, accept them as conclusive evidence of the full action of antimony, for the lowering of circulation and of temperature, and relaxation of vessels, and the analogy of allied medicines (arsenic, digitalis) suggest so forcibly an opposite conclusion (*v.* p. 281). Further experiments are required on this point: meanwhile, I cannot but agree with Rabuteau and

others in classing the drug with those which moderate or diminish the nutritive processes, and which therefore tend to lessen the excretion of urea as well as of carbonic acid. As a curious illustration of the power of antimony to lessen excretion and lower true nutrition, we may refer to a custom common in Germany of using "glass of antimony" in the food to fatten fowls and animals.

Temperature.—There is a similar discrepancy in observations on temperature,—a discrepancy which must depend upon difference in dosage, or in continuance of the medication, or in the reaction of healthy as against weakly subjects. Thus, Ackermann found the hands and face become cold during the period of nausea, but after vomiting they became warmer, and the mouth-temperature did not fall, but increased about 1° F.

Dr. Ringer made a very complete experiment when he gave ½ gr. of tartar emetic every ten minutes for seven hours, inducing vomiting and sweating, and yet the temperature did not vary more than 0.4° F. On the other hand, Pécholier observed the temperature to fall in direct ratio with the pulse, and the amount of fall has been stated at from 1° to 3° C. (Hirtz, Gubler): a brief and slight preceding rise has been noted by the latter physician.

In cases of *poisoning* the depression of temperature is very marked, and in another series of experiments made by Ackermann on animals, it amounted to nearly 7° C. in those that survived a *few* hours.

Nervous and Muscular Systems.—These systems are first excited and then paralyzed by antimony in varying degree according to the dose and the amount of gastric irritation. Restlessness and pain may be at first marked with general tremor and spasmodic contraction of the muscles, either of the abdomen, the jaw, the œsophagus, or extremities, especially of the hands (case of Mrs. Prichard, etc.—cases by Orfila, Elliotson, etc.).

In animals, reflex sensibility is much diminished (Radziejewski), and some degree of motor palsy occurs: these effects, so far as they are central in origin, are spinal rather than cerebral, for they occur equally when the cerebral centre is separated.

They have not been so marked in man, but great muscular prostration is quickly induced, and profound collapse is a characteristic symptom of antimonial poisoning: in some exceptional cases it has been more marked than any irritant symptoms.

There may be temporary loss of consciousness and semi-narcotism (case of Mr. Bravo), or convulsion, and later delirium (Orfila), but usually the mind remains or becomes clear before death.

Fatal Dose.—The minimum fatal dose for an adult may be stated at 2 gr.; for a child, ¾ gr.

The post-mortem appearances have been sufficiently indicated. We need only note further confirmatory evidence of the power of antimony

to produce fatty degeneration in the experiments of Salkowski, who found this change in the viscera of animals after adding 8 to 15 gr. per diem of an antimonial compound to their ordinary food.

Theory of Action.—There has been much discussion as to whether the vomiting and purging which are produced by antimony are due to direct gastro-intestinal irritation, or are secondary to an influence exerted on the nerve-centres (medulla oblongata) by the drug after absorption. The former view was commonly accepted until Majendie's experiment of substituting in an animal a bladder for the natural stomach, and then causing vomiting by intravenous injection of antimony. Such an experiment seemed to prove that emesis was effected through the nerve-centres independently of the stomach; and besides this, the persistence of the nausea seemed to indicate more than an ordinary (mechanical) irritation. Chouppe has also concluded from recent experiments that although antimony may act by such irritation, it more usually acts after absorption. He divided the vagus nerve in dogs; and after subsidence of the retching from the operation, injected antimony into the cellular tissue or veins, and vomiting followed as usual: as an experiment for contrast, he injected in other dogs emetine, and when the vagi were divided this caused no vomiting (Abstract, *Lancet*, ii., 1874, p. 532). Broussais and others, however, always maintained the earlier views as to local irritation, and they are further supported by the following evidence:—(1) Emesis has occurred before any antimony could be detected in the blood (Mayerhofer). (2) In several instances nearly the whole of a dose of antimony has been recovered from the vomited matters—implying that very little, if any, absorption could have occurred before vomiting (Radziejewski). (3) In almost all fatal cases, marked congestion or signs of irritation have been found in the *stomach* after death, and this even when the drug has been given by the veins or other channels. It has clearly been proved that elimination occurs from the gastric membrane under such circumstances, and it is probable that, in Majendie's experiment, the drug was eliminated by the pharynx and by the intestine, and produced vomiting just as if introduced into the natural stomach (Hermann, Grimm, Brinton, Richardson). (4) A smaller dose will produce vomiting when given by the mouth than when given by the veins; this seems a crucial experiment on the point, and, although an opposite statement has been made by some observers, it has been verified by Hermann, Grimm, Kleimann, etc., and it is agreed, of course, that general symptoms occur also after, and in consequence of, absorption, and that nausea and prostration are prolonged in consequence of such absorption.

Another question is, whether the deeply depressing effects of the drug are due to a special "contra-stimulant" action (Rasori), or whether they are only secondary to the emetocatharsis (Broussais). I must conclude

also on this point, that without denying a depressant effect after absorption, and poisoning of the nerve-centres, the muscular tissue, etc., yet the early depression and collapse depend rather on the gastric irritation, the nausea, and the vomiting, and are due to reflex action on the sympathetic and pneumogastric centres. We know that nausea from any cause is accompanied with prostration, faintness, chilliness, and pallor, and antimonial nausea causes the same symptoms in a similar manner, without invoking any speciality in its action (Gubler).

Tolerance, we may explain in some instances, perhaps, by the fact of only partial absorption occurring, *e.g.*, through deficiency in the gastric secretions during fever; but this will not explain it so completely as some have supposed, because the induced feebleness of circulation and respiration, and occasional occurrence of organic lesions, prove that sufficient absorption must have taken place to cause the ordinary effects.

A more reasonable explanation is to be found in the *impaired nerve-condition*, and especially the diminution of reflex excitability in the subjects of "tolerance."

We may say that all those in whom it is evident *at once* (so that they bear "Rasorian" doses of one or more drachms without any pain or vomiting), are either suffering from some neurosis of stomach or vagus, or from some grave malady, as pneumonia, which clearly lowers their vital power: and in those persons in whom tolerance has been slowly induced by the gradual increase of small doses, we may presume that antimony has exerted its known power of diminishing reflex activity, and has thus reduced the patients in this respect to the condition of invalids, even if in other respects convalescent.

Moreover, in many cases of tolerance, though there has been no vomiting, yet diarrhœa has occurred, and the absence of *vomiting*, which is a complex act, may simply mean that reflex nerve-power is too much impaired for its production, diarrhœa being a simpler process.

In women and children, reflex nerve-activity is higher than in the average man, which fact would, according to the previous hypothesis, explain why tolerance is less readily induced in them.

Synergists.—Other emetics, such as ipecacuanha, and other purgatives, such as calomel, increase the effects of antimony. Sedatives, such as bleeding, and more especially digitalis and veratrum, have an allied action: also other medicines which under certain circumstances quiet febrile excitement, as quinine in full doses, arsenic, bromides, citric and tartaric acids.

Antagonists and Incompatibles.—Aromatic, alcoholic, and other diffusible stimulants counteract the depressant effects of antimony. Narcotics, and especially opium, hinder its special action (Rasori)—Gubler, indeed, calculates that opium lessens its power by one-half, and considers it much better to give a half-dose in any case, or to give the narcotic

separately, than to combine such antagonists. Graves, however, has proved a clinical value in the combination, and Laennec found antimony better borne when conjoined with opium and aromatics.

Cold acts as a partial preventer of vomiting, and warmth, of diarrhœa.

Mechanical antidotes are such as oil, thickened milk, and mucilaginous substances: and tannin, in all its forms, is a powerful *chemical* antidote: decoctions of oak and cinchona bark, gall-nuts, strong tea, etc., may be used, and life has been saved by these agents in apparently hopeless cases of poisoning.

THERAPEUTICAL ACTION (EXTERNAL).—The ointment acts as a strong local irritant, and was much employed when counter-irritation was more highly esteemed than it is at present. The pustulation caused by antimony is more painful, but perhaps more permanent in its good results, than that produced by croton oil.

Phthisis.—In the earlier stages of this disease, when there is evidence of local lung-congestion, with pain and oppression, and in the later stages when acute general symptoms are not urgent, I have known it serviceable. Dr. Hogg recommended its application on plaster, sprinkling about 4 gr. of finely powdered tartar emetic upon the surface of an ordinary warm "pitch-plaster:" in the course of a few days this produced much irritation and a crop of pustules. It seems rather severe treatment, but is sometimes beneficial (*British and Foreign Review*, ii., 1860, p. 382).

Meningitis—Hydrocephalus.—In these maladies, the ointment has been applied over the shaven scalp, but the results certainly do not compensate for the suffering caused.

Orchitis—Ovaritis.—Frictions with the ointment have been made in orchitis, along the line of the spermatic cord as far as the scrotum, the skin having been previously punctured. M. Isaac reports well of this procedure (*Practitioner*, 1869), but I cannot think it desirable; it has proved unsuccessful under my own observation. Dr. Rigby speaks very highly of the good effect of counter-irritation by antimonial ointment in ovaritis ("Diseases of Women").

Nævus.—Mr. Bateman recommends a resin plaster made with two parts to one of tartar emetic, and applied over the nævus until inflammatory action and pustulation occur (*Lancet*, ii., 1869). I have several times pursued with success a similar plan.

Lupus—Cancer.—The chloride of antimony has been employed as a destructive caustic for these growths, but is now practically superseded.

THERAPEUTICAL ACTION (INTERNAL).—The double power of antimony to control circulation and nerve-excitement, at the same time that it increases secretion, indicates its use in many diseases, and especially in those of febrile and inflammatory character; on the other hand, the ex-

treme depression that may be caused by it has led to serious results in incautious hands; hence much controversy as to the true value of the drug, and, while by some writers it has been extolled as the best of remedies, it has been described by others as too dangerous a poison to be used.

Forbidden in France by special law in the sixteenth century, it was, not long afterward, received into the Codex, and about the same time our "Earl of Warwick's powder," consisting of the sulphuret of antimony, with cream of tartar and scammony, obtained a wide reputation. The tartrate of antimony and potash was introduced somewhat later (by Mynsicht), and has continued in general estimation and daily use down to our own time.

Within the last twenty years, however, and since the value of tonic and restorative treatment has been better recognized, antimony has, like bleeding and other depressants, been more rarely prescribed, and at present it may be questioned whether its great therapeutical powers are sufficiently appreciated. We do not hold that this, more than other medicines, has a separate or specific action for each of the various diseases we are about to mention,—that it cures convulsion in general, or pneumonia, or rheumatism as separate nosological species (Gubler), but rather that it exerts an exceptionally marked influence on certain pathological states, which either cause or complicate these and many other maladies.

Fevers.—At the commencement of an attack, when gastric disorder was very marked, an antimonial emetic was formerly much commended. Dr. Gregory often employed it in these circumstances, but he also pointed out the danger of inducing irritability of the stomach, and even inflammation. Dr. Graves and others have taught that such an emetic, given within thirty-six hours of the initial rigor, would often abort the fever, but this is difficult to prove, and is not generally accepted. Modern practice has rather taught us that nausea and vomiting are usually needless annoyances to the patient, though if induced in the early stages vomiting may certainly relieve headache and severe gastric congestion when dependent upon accumulated mucus and bile.

Dr. Graves originated, and highly praised also, the administration of antimony in fever (especially *typhus*) at a stage when cerebral complications are sometimes very severe, *e.g.*, from the seventh to the ninth day. Thus, to a strong adult, suffering with complete insomnia, illusions of the senses, delirium, continued tremor and subsultus, "cerebral" respiration, very quick and weak pulse, sordes, and every symptom of the worst augury, ¼ gr. of tartar emetic in water was given every hour: the patient vomited freely (though not directly) after each of the first four doses, then purging began, the general condition improved, and the man slept: after temporary omission of the medicine, 2 min. of "black drop" (opium)

were given every two hours, and on the following day there was free perspiration, natural sleep, and a rational mind; ultimately a good recovery followed ("Clinical Lectures").

In other equally severe cases the same dose of antimony has been given from the first with 2 or 3 min. of laudanum, and the results have been such as to warrant much confidence in this method of treatment; it is necessary, however, to use it cautiously, and to bear in mind its weakening effect upon the cardiac muscle, which is already enfeebled from the effect of the disease (Murchison).

Enteric Fever.—Antimony has been commended in this fever, but the intestinal condition requires exceptional caution in its use; it does not of itself forbid the remedy, for diarrhœa and pain have often subsided under it (Trousseau), and when the lungs are implicated it may be especially useful.

M. Bériard records a case of fever with secondary pneumonia and delirium, rapidly passing into a hopeless comatose condition, which was relieved at once by free vomiting and purging from a large dose (nearly 6 gr.) of tartar emetic, and ultimately recovered (*Bulletin de Thérapeutique*, 1873).

Intermittent Fever (*Ague*).—The paroxysms may sometimes be prevented by an emetic dose of antimony, but this is not a special effect of the drug, for it will occur after the use of other emetics.

Scarlet Fever—Measles—Small-pox.—In these disorders, especially when the eruption is scanty or suppressed, antimony may be useful by determining to the skin, and thus relieving the febrile condition and obviating grave symptoms.

I have given tartar emetic in small-pox in varied doses, but have never known it exert a modifying influence on the disease itself. In certain complications, however, such as pneumonia, bronchitis, or acute delirium, doses of $\frac{1}{16}$ to $\frac{1}{4}$ gr. every two or three hours, have given relief.

Antimony is exceedingly useful in the bronchial catarrh which is often a serious complication of measles: besides controlling the general pyrexia, it relieves the oppression of the chest, acts as an expectorant, and tends to diminish a too abundant secretion of mucus, probably by lessening congestion.

If $\frac{1}{2}$ gr. of tartarated antimony be dissolved in 4 oz. of distilled water, a teaspoonful may be given frequently or occasionally, according to the severity of the cough or the oppression. In the case of weakly children, the amount of depression which may be induced requires to be carefully watched.

"*Worm Fever.*"—In remittent pyrexial conditions dependent upon intestinal worms, I have found small doses beneficial, but the emetic action of the drug, as a rule, is undesirable.

Rheumatic Fever.—Laennec, Bricheteau, and other eminent physi-

cians of a past generation, advocated the use of large and repeated doses in acute rheumatism, but later experience is against their adoption. I formerly used ¼ gr. doses with advantage, especially when the temperature was not very high. Barbeau quotes cases illustrative of its value in acute rheumatism, when used as an evacuant previous to commencing quinine (*Medico-Chirurgical Review*, i., 1857, p. 266).

Lumbago.—In obstinate cases of ordinary lumbago and local muscular rheumatism, I have ordered the same dose every one or two hours for a short time with excellent results.

Erysipelas.—Desault recommended the frequent use of minute doses of antimony in erysipelas, giving 1 gr. dissolved in a quart of water in the course of twenty-four hours. Dr. A. J. Walsh has reported a number of satisfactory results under this treatment (*Dublin Quarterly Journal*, August, 1850), but I consider other remedies act still better.

Traumatic Pyrexia.—In febrile conditions resulting from severe injury, antimony has been found useful. Thus, Mr. Denny found it "act like a charm" in a case of gun-shot wound of the chest with inflammatory reaction, rigors, delirium, etc.: some nausea was induced, the pain quickly subsided, and in twelve hours the fever aborted, and sleep set in (*British Medical Journal*, i., 1871). Speaking, however, from large experience, I am satisfied that aconite is a more trustworthy remedy in such cases.

Acute Inflammations—Orchitis, Tonsillitis, etc.—In minor local forms of inflammation, such as of the breast or testicle, of the tonsil or parotid, or of a varicose vein, the good effect of small doses of tartar emetic is often conspicuous. Dr. Beatty especially noted their power of controlling mammary inflammation, as if by "specific action on the gland." After purgation, he gave $\frac{1}{16}$ gr. every hour, never desiring an emetic action, but not objecting to slight nausea (*Dublin Journal*, vol. iv.). Dr. Churchill found the same plan "more effective than any other" (Midwifery). A case of inflamed varix cured by this method is related by Dr. Spender in his essay on the advantages of small, frequent doses (*British and Foreign Review*, 1872), and he believes that the dose may be adjusted with mathematical precision and certainty: "$\frac{1}{20}$ to $\frac{1}{16}$ gr. given every hour is bound to control a local phlegmon." I have found it good in tonsillitis and parotitis, the pain, congestion, and pyrexia being often quickly relieved, and yet this is not the treatment I usually adopt, nor do I think it so good as that by aconite or belladonna.

Purulent and Strumous Ophthalmiæ.—In these affections, tartar emetic was a usual remedy some years ago, and doubtless acted by abating local congestion; modern practice, however, places more reliance on the use of topical remedies and of tonics.

Acute Eczema.—When this malady occurs in persons of full habit—especially if also of gouty tendencies—and when pyrexia, severe local

irritation, gastric disorder, and loaded urine are present, I have seen much advantage from combining antimony with magnesia or other saline aperients, or with diuretics. Meade also writes in its favor (*British Medical Journal*, ii., 1864).

Bronchitis.—Tartar emetic seems to me to exert almost a specific effect on inflamed bronchial membrane. In the case of old people it is useful especially when the cough is convulsive in character, most troublesome at night, and attended with loud wheezing respiration, paroxysmal dyspnœa, and profuse secretion of mucus which is, with difficulty, expectorated. When inflammation affects the smaller tubes of young adults, an emetic dose may be found sometimes desirable, but as a rule, $\frac{1}{16}$ to $\frac{1}{8}$ gr. every two to three hours will suffice to render free and less tenacious the bronchial secretion, to lower the blood-tension, diminish pyrexia, and relieve local congestion and oppression. The action of the skin and of the kidneys is increased usually in inverse ratio—if one is more, the other is less marked. If cough be very severe, a little morphia or belladonna may be combined with the antimony, while in later stages, if more stimulus to expectoration is needed, squill is a useful adjunct.

In the *capillary bronchitis* of children, tartar emetic often proves valuable. I have treated with it nine cases during the last season; all were under two and a half years old, and suffered with distressing paroxysmal cough, which caused much exhaustion; the respiration was much quickened, the pulse 130 to 140, small and feeble, the temperature 101° to 103° F.; there were the ordinary physical signs in the lungs, the face was dusky and œdematous, the skin covered with a clammy moisture; restlessness was extreme, and cerebral symptoms, such as sopor, delirium, and even (in some) coma, were present; these patients were ordered small but frequent doses, $\frac{1}{64}$ gr. every half-hour for four doses, afterward every one to three hours, according to the amount of cough or oppression: of the nine cases, four vomited within two hours of the first dose, and all showed signs of exhaustion under the medicine, but all of them made good recoveries.

Pneumonia.—The proper treatment of this disease has long been a crucial question, and opinions have varied as to the amount of influence possessed over it by antimony. Very much depends upon the time and mode of administration. Rasori, with his "contra-stimulant" method, aimed at exciting, in or near the inflamed part, an artificial irritation, more powerful than the original disease, and gave from the commencement large doses, which he rapidly made enormous. Thus, one adult was ordered on the first day about 24 gr., and by the eighth, 144 gr. per diem; the amount was then reduced up to the twelfth day, when death occurred: the same patient was bled several times in the course of the attack, this being considered to favor the special action of the drug; there was no evidence of its irritant effect, but such a mode of treatment

could not be sanctioned at the present time; and although the mortality in the practice of the Italian physician was less than that of his contemporaries, it was yet very large, and must not be taken as illustrating the results of a judicious use of antimony.

Laennec usually recommended 1 gr. every two hours till 6 gr. had been taken, and then an intermission for the same period; sometimes, however, he increased the dose gradually to 30 gr. in the twenty-four hours. His mortality was about one in twenty, reckoning only well-marked cases; that of Louis, following a very similar method, was about three in twenty. Trousseau and Grisolle, who have treated the subject fully, agree in speaking highly of this antimonial treatment, the former, indeed, so highly, that he foresees "a future generation will tax him with exaggeration." The latter observer has specially analyzed forty-four cases, showing some strikingly good results as to relief of signs and symptoms and as to brief duration, but these reports must be read in the light of our later knowledge of the *natural history* of pneumonia, which would explain some of the rapid recoveries by the occurrence of a natural crisis: vomiting and purging were often caused to a serious extent (cf. Sturges: "On Pneumonia," Appendix G, "Treatment Statistics").

Dr. W. Stokes was one of the earliest British physicians to report favorably of this remedy in pneumonia; he stated that it acted better when given before hepatization had commenced than afterward. Sir Thos. Watson also commends it, specially in the stage of engorgement, and Dr. Walshe lays stress upon its value when it is not given to emesis. Dr. C. J. B. Williams uses $\frac{1}{8}$ to $\frac{1}{2}$-gr. doses every two, three, or four hours during the early stages, combining them with citrate or nitrate of potash (Lectures, *Medical Times*, i., 1872).

Three grains is the minimum, and 16 the maximum daily dose recommended by the German Codex, and these quantities nearly accord with those already mentioned: with them vomiting has generally been observed at first, and is said to have proved useful rather than otherwise, and, later on, tolerance has become established so that irritant effects have not been marked; nevertheless, smaller doses are to be preferred. I have found the best results from those ranging between $\frac{1}{60}$ and $\frac{1}{4}$ gr. given every two to three hours, beginning with the smaller amount and increasing gradually so as to produce general effects without vomiting or even nausea. In severe cases, with high temperature, small frequent doses of *aconite* are valuable in combination or alternation with antimony (*v.* Vegetable Kingdom), and I believe by this treatment may be effected all the good Rasori expected from preliminary bleedings. In moderately severe attacks, with less pyrexia, antimony alone is a good and sufficient treatment from the first, although its special value is shown best when "resolution" begins; it assists the clearing up of consolidated lung. Another indication for the remedy is to be found in the presence of various complications, such

as bronchitis, or whooping-cough, or when the malady deviates from an ordinary course, or occurs after influenza or in emphysematous subjects; then I have reason to express the greatest confidence in it. It is true that Nothnagel, Nöbiling, and others, hold a different opinion, but this may be attributed partly to giving larger doses than the patients could bear, partly to the indiscriminate use of the medicine in all stages and phases of the disease; for Nöbiling speaks of emetic doses which induced *cardiac collapse*, and of small doses being continued till *intestinal ulceration* occurred, results of which I have never seen any indication under the method above recommended. I must, however, guard myself from seeming to imply that it is the only or the best treatment for every individual case: in exhausted broken-down subjects the appropriate time for it is but short, and ammonia, bark, phosphorus, and alcohol must soon replace it, while in septic forms of the disorder, which indeed are not infrequent, tinct. ferri-perchloridi is rather indicated.

In the serious *lobar pneumonia*, as it commonly affects young children, many authors—Stillé, for instance—question the propriety of giving antimony in any dose, because of the risk of sudden depressing effects; this must be borne in mind, but yet I have myself seen the remedy so efficient that I advise its employment very much as in the lobular form connected with capillary bronchitis.

Dr. George Buchanan, while hesitating to recommend antimony as a usual treatment, records that he has seen more benefit from emetic doses of it given at an early period ($\frac{1}{6}$ to $\frac{1}{4}$ gr. every quarter-hour till vomiting occurred), than from any single remedy; it seemed to control the severe symptoms, and secure a favorable after-progress (*Lancet*, i., 1868); this is, of course, one mode of using the drug, but I prefer minute continued doses.

In cases of *phthisis with intercurrent acute pneumonic attacks*, the remedy is often as useful as in the idiopathic malady, but special care must be taken to avoid emetic or irritant effects, because of the possibly tuberculous condition of the intestine. In "incipient phthisis," during the stage of cachexia with febrile reaction, small doses lessen irritation and congestion; and even, in the developed malady, when there is general pyrexia, and constant irritative cough, it often relieves, rendering the cough "softer" and expectoration easier.

Inflammatory or True (Membranous) Croup.—In this serious disease antimony often proves useful, especially in the early stages. It first obtained its reputation at a time when spasmodic and catarrhal croup were not well distinguished from the more serious malady, and when recovery from those varieties was reckoned as recovery from true croup; but at present, on account of its depressing effects, most physicians limit its use to a few emetic doses in cases with very severe spasm, and evident obstruction from false membrane (Klemm: Schmidt's *Jahrb.*, Bd. clx., s. 45).

Dr. Elliotson, however, records cases occurring in infants, and treated successfully with ¼ and even ½-gr. doses every four hours—in one case 27 gr., and in another 33 gr. being taken: vomiting occurred, and some tetanic spasm, but good recovery was made from critical conditions. Mr. Meek and others report in the same journal cases where ½-gr. and even 1 gr. doses were given with favorable results to children of four and seven years; but, on the other hand, Mr. Kesteven and others record injurious effects (*Medical Times*, ii., 1856). Professor Bouchut advocates giving ⅙ to ⅓ gr. frequently, until emesis and diarrhœa are produced, and he records several cases of recovery in the second and third stages (*Journal für Kinderkn.*, May and June, 1861, *Lancet*, ii., 1872).

I cannot adopt the above doses as quite safe, and think that great caution should be exercised as to their use. I recommend rather a solution to be made with 1 gr. in 4 oz. of water, and of this one teaspoonful (1/32 gr.) may be given every half-hour for four or five doses; it will often suffice to excite vomiting, which, however, is not desirable unless there be evident obstruction in the trachea; so soon as this obstruction is lessened, the remedy should only be given at intervals of two to three hours; the dyspnœa is commonly removed for a time after vomiting, but if it recur, the same effect should be induced again: of course, the patient's strength is to be supported by suitable nourishment, and fomentations, sprays, or other adjuvants may be used. With this plan of treatment I have many times noticed an early abatement of the cough, dyspnœa, and hoarseness, lowering of the pulse-rate, return of natural warmth and color, and quiet sleep. It is true that the sulphate of copper is often preferred as an emetic, but under the sole use of antimony, as described, I have seen very severe and advanced cases relieved, and if the dose mentioned be found really too small in a given instance, it may be cautiously increased.

Nephritis.—In acute nephritis, whether induced by cold or by fever, antimony has been specially commended by Dr. Bence Jones, Dr. Barlow, and others (*Guy's Reports*, vol. x.). It would certainly seem, *à priori*, that the action of small doses on the skin and the intestinal tract, as well as on the inflamed organ, should be of favorable character, but practically I have seldom found it to be so. Tartar emetic does not appear to exert any direct special power in controlling disease of the genito-urinary mucous membrane.

Spasmodic Croup — Laryngismus Stridulus. — Antimonial emetics have been very strongly recommended to arrest the paroxysms of this malady (Stillé), but yet, remembering its clear connection with rachitis and impaired nutrition, tartar emetic is not the remedy we should choose for curing its essential cause: bromides, belladonna, and cold bathing, with tonics and nutrients, are more indicated.

Muscular Spasm—Rigidity of Os Uteri—Colic.—Muscular spasm,

such as occurs in dislocations, herniæ, etc., may certainly be relieved by emetic or nauseant doses of antimony, and these were, at one time, commonly employed.

In difficult labor connected with rigidity of the muscular structure of the cervix uteri and perineum, relief may also be given by the same means. Dr. Kennedy, of Dublin, strongly recommended this treatment, and Dr. Gilmour (Liverpool) quoted a large experience in its favor; he claimed for it also, not only an immediate favorable effect, but a good influence on the after-progress of the case, finding marked freedom from subsequent inflammations, etc., where it had been used (*Lancet*, ii., 1852): practically, however, chloroform has superseded it.

For *Intestinal Colic*, tartar emetic has sometimes been given successfully by enema. In a case dependent upon obstruction, 3 gr. dissolved in 8 oz. of water were injected per rectum, and, after some hours, the obstruction yielded and the colic subsided, without additional nausea or prostration (*Lancet*, i., 1856, p. 96).

Constipation.—In obstinate cases connected, in part at least, with deficient intestinal secretion, and occurring especially in old people, small doses of tartar emetic will assist the action of saline purgatives such as sulphate of magnesia. Dr. Nevins has recorded a good illustration of this, and finds that less than ¼-gr. doses will usually suffice ("Comment., Lond. Pharm.").

It has been maintained by some distinguished writers (Gubler, Chomel, Rayer, etc.), that not only the above-described but all other therapeutical effects of antimony are dependent upon, or connected with, its emetic, or at least its nauseant action, and are explained either by an elimination of morbid material, or by the profound disturbance and subsequent reaction induced in the economy; but—not to speak of the older cases in which benefit was conferred during "tolerance," *i.e.*, when there was little or no vomiting—I am satisfied that most maladies are better treated by small and frequent doses, which do not cause vomiting, and that only a few cases require the production of nausea.

Mania—Melancholia.—There can be no doubt that the large doses—12 to 30 gr.—formerly given to patients with mental disease, and especially to those suffering from acute or violent mania, served the purpose of quieting their violence for a time, but the general results were rather injurious (Greisinger), and professional opinion is justly opposed to producing temporary quiet by this means (Bucknill). A smaller quantity, however—½ to 1 gr., thrice daily—I have often known to be well tolerated by men who are in fair bodily health, and it certainly acts better when nausea and depression are not induced. The same observation has been made by Schroeder van der Kolk, a deservedly high authority: he has seen marked benefit from the remedy, and recommends it in pill after meals (to avoid vomiting), the dose to be cautiously increased from ¼ gr.

In *Puerperal Mania* the last-named physician has also found small repeated doses very useful, and Dr. E. Kennedy recommends them especially for phlegmatic patients (*American Journal*, v. 17). Dr. Madden has seen doses of $\frac{1}{8}$ gr. every four hours act very favorably, subduing delirium in a comparatively short time; sometimes he has used doses of 1 gr., which quieted excitement still more quickly, but were liable to depress the heart-action unduly (*Medico-Chirurgical Review*, ii., 1871).

Puerperal Convulsion.—For convulsions occurring in vigorous, muscular subjects, with high arterial tension, it is possible that antimony may be sometimes indicated. It has been, with advantage, combined with bromide of potassium (*Practitioner*, ii., 1869). Before the latter drug came into use, I often had recourse to antimony, and in cases connected with renal disorder I observed relief, mainly owing, as it seemed, to increased activity of the skin and intestinal glands.

Hypochondriasis—Mental Depression.—In these conditions antimony has been commended, but can only act favorably through the strongly stimulating effect of emetic doses, and modern practice seldom resorts to this treatment.

Epilepsy.—Like so many other medicines, antimony has been applied in the treatment of epilepsy, especially, but not only, in plethoric subjects (Cheyne, Bell, etc., *Glasgow Medical Journal*, October, 1857, Ranking, 1858).

Delirium Tremens.—Though antimony is seldom now prescribed for this condition, the good results obtained from it, by Dr. Peddie especially, require some notice. He speaks of uniform success in upward of eighty cases, treated mainly by $\frac{1}{2}$ to $\frac{1}{4}$-gr. doses, given every two hours until improvement set in; emetic action was not marked, but occurred to some extent with the early doses: secretion from the kidneys and the skin was increased, but he attributed the benefit rather to a sedative effect on the nervous system and the lowering of vascular excitement (*Edinburgh Monthly Journal*, 1854). In America and in Germany, larger doses have been successfully used—Schroff, for instance, giving 4 to 6 gr. daily, and others the same dose every hour. The practice, however, is dangerous, because in this malady the circulation fails so readily, and Dr. Anstie has pointed out that antimonial treatment, though certainly successful in some cases, has ended unfortunately in others ("Reynolds' System," ii., p. 92). I have found its moderate use valuable in young robust men, especially in the first attack, and even when much gastric derangement was present: it is not so suitable for old or debauched subjects.

Chorea.—The emetic action of antimony has been utilized for the relief of chorea, and the influence of the remedy has been explained as reflected through the vagus nerve to its central origin in the medulla, inducing sedative effects in that part (Ringer). Boulay and others have recorded successful cases from the use of nauseating doses (*Bulletin de*

Thérapeutique, v., 52–4, *London Medical Review*, 1861), and Dr. West recommended it, but I cannot consider it a desirable treatment, nor is the evidence in its favor very strong. Comparing it with arsenical treatment in twelve cases in Parisian hospitals, only half the number were reported cured by antimony, and some of these lasted long enough at least for natural recovery (fifty-eight days); whereas of eleven cases treated by arsenic all got well (M. Long). Of course, in comparisons of this kind we must make some allowance for the tendency of chorea to recover under judicious management, independently of medicine, but the general evidence in favor of arsenic much outweighs that in favor of antimony.

Asthma.—Some forms, especially of dry spasmodic asthma, are much relieved by repeated small doses. Dr. Ringer has noted their value in attacks of wheezing and orthopnœa of asthmatic character to which some children are subject after exposure to cold, and which sometimes follow measles. In such cases he recommends one teaspoonful every quarter-hour of a solution containing only 1 gr. in ½ pint of water: even this amount may cause vomiting, though that effect is not necessary for relief. Dr. Koch has remarked that the remedy is most useful when the attacks are brought on by peripheral irritation (cold, etc.), rather than by emotional causes; and he speaks highly of a combination with arsenic acid—the arseniate of antimony—which he administers in the form of vapor from a cigarette (*Practitioner*, vol. iv.).

Emphysema.—Dr. Koch has found the same salt act well as a nervine and muscular tonic in emphysema; and, according to my experience, it certainly deserves further trial.

Contra-Indications.—General feebleness, and especially feebleness of the circulation or of the digestion, would usually prevent the giving of antimony; hence it should rarely be prescribed in *infancy* or in *advanced life*. To children it has proved specially dangerous sometimes, by inducing a condition of collapse without much warning, but a remedy so valuable in their acute inflammatory affections, should not be wholly withheld: in old persons it is more liable to derange the stomach. Before emetic doses are ordered for a patient, inquiry should be made, if possible, as to the existence of hernia, aneurism, or other arterial or cardiac disease, cerebral congestion, uterine displacements, or pregnancy: such conditions should contra-indicate the production of vomiting.

Preparations and Dose.—*Antimonium sulphuratum:* dose, 1 to 5 gr. as an *alterative*; 10 to 20 gr. as an *emetic*. Is seldom prescribed unless in the compound calomel pill (Plummer's). *Antimonium tartaratum:* often given dissolved in plain water, but the pharmacopœial solution of it is a "*vinum antimoniale*" containing 2 gr. to the ounce. This is convenient for giving small doses of the drug, especially in febrile conditions, but is not very suitable when larger quantities for depressant effects are required. Dose: *as diaphoretic and expectorant*, $\frac{1}{16}$ to $\frac{1}{6}$ gr. of the powder,

or 15 to 40 min. of the wine every one to three hours; for children, smaller doses (*v.* pp. 291–4); *as vascular depressant or sedative*, $\frac{1}{16}$ to 1 gr.; *as an emetic*, 1 to 2 gr. and upwards. *Unguentum antimonii tartarati* (contains 1 part of tartarated antimony to 4 of simple ointment). *Antimonii oxidum:* dose, 1 to 4 gr. *Pulvis antimonialis*, the officinal substitute for James's powder: dose, 3 to 10 gr.—the latter dose causes vomiting. *Liquor antimonii chloridi:* used only as a caustic. *Antimonium nigrum:* not used except in the preparation of antimonium sulphuratum, and liquor antimonii chloridi.

[PREPARATIONS, U. S. P.—*Antimonii et potassii tartras* — tartar emetic. *Emplastrum antimonii:* tartrate of antimony and potassium 1 troyounce, Burgundy pitch 4 troyounces. *Unguentum antimonii:* tartrate of antimony and potassium 100 grains, lard 400 grains. *Vinum antimonii:* tartrate of antimony and potassium 32 grains, boiling distilled water 1 fluidounce, sherry wine, sufficient to make 1 pint. *Antimonii oxidum; Antimonii oxysulphuretum:* dose 1 to 3 grains. *Antimonii sulphuretum*, used in preparations *Antimonium sulphuratum. Pilulæ antimonii compositæ:* sulphurated antimony, mild chloride of mercury, each 12 grains; guaiac., molasses, each 24 grains. Divide into 24 pills: dose 1 to 3 pills.]

ADULTERATIONS.—The powdered tartar emetic may contain free tartrate of potash, lime, copper, iron or arsenic.

END OF VOLUME I.

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